Reconstructing the Summer Thermal History for the Lower Fraser River, 1941 to 2006, and Implications for Adult Sockeye Salmon (*Oncorhynchus nerka*) Spawning Migration

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RECONSTRUCTING THE SUMMER THERMAL HISTORY FOR THE LOWER FRASER RIVER, 1941 TO 2006, AND IMPLICATIONS FOR ADULT SOCKEYE SALMON (*Oncorhynchus nerka*) SPAWNING MIGRATION

by

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ABSTRACT

Patterson, D.A., Macdonald,J.S., Skibo, K.M., Barnes, D.P., Guthrie, I., and Hills, J. 2007. Reconstructing the summer thermal history for the lower Fraser River, 1941 to 2006, and implications for adult sockeye salmon (*Oncorhynchus nerka*) spawning migration. Can. Tech. Rep. Fish. Aquat. Sci. 2724: vii + 43 p.

An extensive amount of water temperature data has been collected from the Fraser River since the 1940s. Temperature records are primarily from the Fraser River at Hells Gate; but many other lower river locations have been monitored. Our objective was to create a complete dataset of the Fraser River daily mean temperatures between June 1st and September 30th for 1941–2006 at Hells Gate. We compared data collected at Hells Gate with datasets from nearby locations to identify which locations would provide reasonable surrogate data for missing values in the Hells Gate dataset. After verification, all data were ranked based on quality, and a near complete Hells Gate dataset was reconstructed using the most suitable data. Of the 8052 possible daily mean temperature values from 1941–2006 (June through September) we compiled 6909 values or 86%. The thermograph for June through September for the Fraser River is now based on an average of 62 years for each date (out of possible 66 years) from 1941–2006. We examined the annual variability in lower Fraser River temperatures during to the adult sockeye salmon (*Oncorhynchus nerka*) migration period for the four major run timing groups. During the overall summer migration period temperatures have ranged as much as 10°C since 1941 with large interannual variability. Variability among years did not mask large differences among decades. The 1940's were warm followed by a much cooler 1950's and 1960's and decadal averages have increased since. The average temperatures (±SD) experienced since 1941 by four sockeye run timing groups using a 19-day period centred on the historic average timing were as follows: Early Stuart 15.8 ± 1.4 °C; Early Summer 17.5 ± 1.1 °C; Summer 17.4 ± 1.1 °C; and Lates 13.6 ± 1.1 °C. The Early Stuart, Early Summer and Summer run-timing group are facing more strenuous migrations as environmental conditions worsen due to increasingly warmer temperatures. Late-run sockeye are currently experiencing the largest increase in thermal exposure due to warming temperature and a dramatic advance in river entry timing. Since 1995 their average temperature during migration has increased to 16.5 °C. The future survival of each run timing group to the predicted increase in water temperature will likely be a function of their capacity to adapt both behaviourally and physiologically to higher temperatures.

RESUMÉ

Patterson, D.A., Macdonald,J.S., Skibo, K.M., Barnes, D.P., Guthrie, I., and Hills, J. 2007. Reconstructing the summer thermal history for the lower Fraser River, 1941 to 2006, and implications for adult sockeye salmon (*Oncorhynchus nerka*) spawning migration. Can. Tech. Rep. Fish. Aquat. Sci. 2724: vii + 43 p.

Depuis les années 1940, la température de l'eau du Fraser a été mesurée à de très nombreuses reprises. Les mesures ont principalement été effectuées au niveau de Hells Gate mais de nombreux autres endroits du cours inférieur ont également été surveillés. Notre objectif a été de créer un ensemble de données concernant les températures quotidiennes moyennes du Fraser entre le 1er Juin et le 30 Septembre pour la période 1941-2006 au niveau d'Hells Gate. Nous avons comparé les résultats obtenus à Hells Gate avec ceux de zones situées à proximité pour identifier quels sites pouvaient fournir des données appropriées en remplacement de celles manquantes dans la banque de données d'Hells Gate. Apres vérification, toutes les données ont été classées en fonction de leur lien avec celles d'Hells Gate; un jeu de données d'Hells Gate presque complet a ete reconstitué grace aux données les plus appropriées. Nous avonc compilé 6909 des 8052 valeurs possibles des températures quotidiennes moyennes de la période 1941-2006 (de Juin a Septembre), soit 86%. Désormais, la courbe représentant la température du Fraser de Juin a Septembre s'appuie sur une moyenne effectuée sur 62 ans, de 1941 à 2006, pour chaque date (sur 66 ans possibles). Nous avons examiné la variabilité annuelle des températures dans le cours inferieur du Fraser lors de la migration des quatre groupes majeurs de saumons rouges adultes effectuant leur migration à des périodes différentes. Sur l'ensemble de la période de migration estivale, des écarts de 10°C ont été enregistrés depuis 1941, avec une forte variabilité interannuelle. La variabilité interannuelle n'a pas masqué de fortes différences entre les décennies. Les années 1940 ont été chaudes en comparaison des années 1950 et 1960, plus fraiches. Les moyennes par décades sont en augmentation depuis cette époque. En considerant une période de 19 jours centrée sur la date historique moyenne de migration, les quatre groupes de saumons rouges de date de migration différente ont été confrontés aux températures moyennes suivantes (± EM): Early Stuart 15.8 ± 1.4 °C; Early Summer 17.5 ± 1.1 °C; Summer 17.4 ± 1.1 °C; and Lates 13.6 ± 1.1 °C. Les differents groupes de migration Early Stuart, Early Summer et Summer doivent faire face à des migrations de plus en plus difficiles car les conditions environnementales se déteriorent du fait de l'augmentation des températures. Les saumons rouges de migration tardive subissent les températures les plus élevées et une date d'entrée dans le fleuve très précoce. Depuis 1995, la température moyenne à laquelle ils sont exposées a atteint 16.5 °C. La survie future de chaque groupe de migration, dans le contexte de l'augmentation prévue de la température, dépendra fortement de leur capacité à adapter leur comportement et leur physiologie aux températures plus élevées.

INTRODUCTION

Water temperature has a profound effect on the physiology of all aquatic organisms. Long-term changes in thermal regimes, associated with climate change, are likely to have a demonstrable impact on aquatic ecosystems (Meyer et al. 1999). Despite the biological importance of water temperature, there is a paucity of long-term water temperature data. Our ability to assess biological fitness to rates of climate change and the natural variability of thermal regimes is impaired. The Fraser River is one of a few watersheds in North America with a sizeable historical temperature dataset that could be used to assess climate change impacts (Foreman et al. 1997).

Fraser River temperature data has been collected by many agencies for many reasons at a variety of locations using different equipment and methods and exists in many discontinuous and incomplete datasets. We used the best available data to reconstruct the thermal history of the Fraser River at a single location. The most continuous record of temperature was collected by the Pacific Salmon Commission (PSC), formerly known as International Pacific Salmon Fisheries Commission (IPSFC), at Hells Gate from 1941 to 2003. However, methods changed over the years and the data records were not complete. We reconstructed a Hells Gate water temperature dataset using data from other lower Fraser locations to augment and verify the Hells Gate record. Data were verified for quality and inter-location correlations were established.

The Fraser River has the largest abundance of salmonine fishes of any single river system in the world (Northcote and Larkin 1989). There are seven species of Pacific salmon that use the watershed. Of the seven species, sockeye salmon (*Oncorhynchus nerka*) arguably form the most important cultural and economic fisheries within the Fraser River. For this reason, we used sockeye salmon as the focal species to document the changes in the thermal ecology during the return adult migration period over the past 65 years. Major scientific and judicial investigations into the Fraser River sockeye salmon fishery have investigated the discrepancy between estimates of lower river escapement and spawning ground escapement, including: 1992, 482,000 sockeye (Pearse and Larkin 1992); 1994, 800,000 sockeye (Fraser 1995); 1998, 3,390,000 sockeye (Macdonald et al. 2000), and 2004, 1,300,000 million sockeye (Williams 2005). Each of these reviews attributed en route loss caused by warm water temperatures as a plausible reason for a portion of the discrepancy in estimates. The biological basis for their conclusions came from numerous studies that have highlighted the importance of water temperature on different physiological processes in migrating salmon, such as disease (Sanders et al. 1978), reproduction (Pankhurst et al. 1996), and swimming performance (Lee et al. 2003). Given the impact that temperature has on migration success, it is imperative to accurately quantify the thermal history of the Fraser River, as this knowledge will enhance our ability to forecast salmon survival and develop management strategies to potentially mitigate against future losses.

This report reconstructs a long-term water temperature record for the lower Fraser River at Hells Gate from June 1st to September 30th. This is the spawning migration period for most Fraser River adult sockeye salmon. Data limitations with respect to collection methods, missing data, and site comparisons are documented. We discuss the changes in the thermal history of the Fraser River and how this relates to migration conditions experienced by the four major adult sockeye salmon run timing groups.

MATERIALS AND METHODS

We compiled all known temperature datasets for locations in the lower Fraser River south of Hells Gate (Figure 1) from 1941 to 2006 for the months from June to September. Hells Gate daily mean or spot temperatures were compared to contemporaneous data from nearby locations to assess similarity for the purposes of providing surrogates for data missing from the Hells Gate dataset. Data quality was verified by ranking locations based on their annual consistency. A Hells Gate dataset was reconstructed by filling gaps or replacing poor quality data in the original dataset with temperature values from verified sources.

INSTRUMENTS USED FOR TEMPERATURE MEASUREMENT

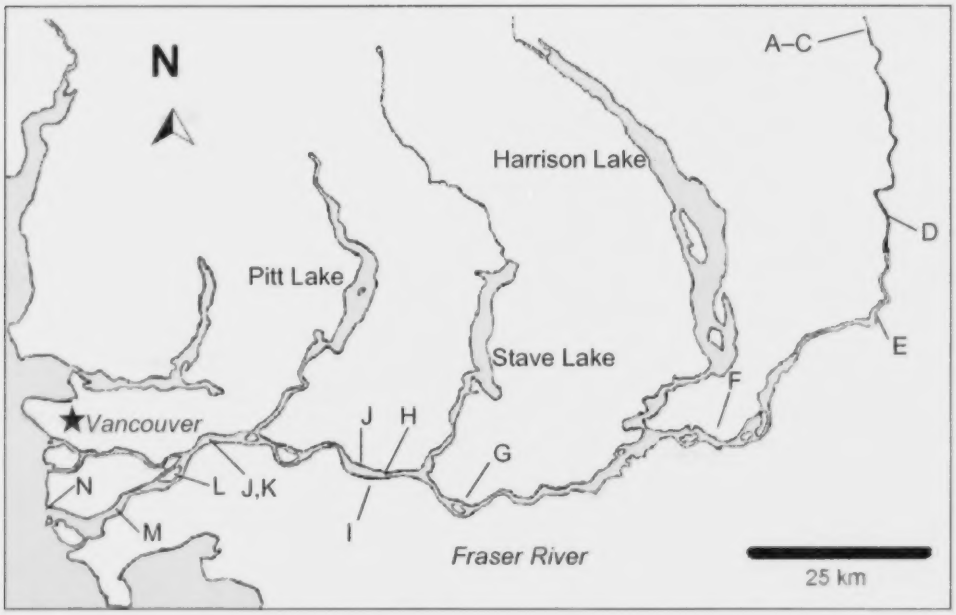
Methods for measuring water temperature varied by location and changed over time (Table 1). Hand-held thermometers were most commonly used. Thermometer readings at Hells Gate (200 km upstream from the mouth of the Fraser River at Steveston; note that all distances reported hereafter are relative to Steveston) began in the summer of 1941 on nearly a daily basis, at approximately 10:00 PST each day. Hand-held thermometers were used to collect daily water temperatures during test fishing operations which generally occurred during the slack period of the daytime high tide. Time of measurements, in these cases, varied based on the tide cycles. Thermometers have also been used for calibration of other measuring instruments (Table 1). Unfortunately, the resolution of the hand-held thermometers was rarely available in the historical datasets but likely ranged from 0.1–1 °C. Thermographs were also used to record temperature (mfg.: Taylor, Bristol, and Foxborough) (Gilhousen 1990) which unlike other systems recorded in Fahrenheit. Unidata electronic logger with external thermistors (Model 6003, 6004-2; thermistor probes: Unidata Model 6507A Red) (Lauzier et al. 1995), and real-time loggers (Fireweather Plus, v. 4.04.2; mfg.: Forest Technology Systems) which use external thermistors and land line transmitters (Barnes and Walthers 1997). Vemco, Trend Reader and Stowaway full immersion data loggers (self contained electronic systems) with memory microprocessors (Barnes and Walthers 1997) have also been used on the lower Fraser River at various locations (Table 1).

Table 1. Summary of methodologies for sampling water temperature from 1941 to 2006 including: sampling location (Codes in Figure 1), measuring instrument, period of sampling, frequency, resolution, accuracy, measurement scale (C = Celsius, F = Fahrenheit), and the agency responsible (DFO = Fisheries and Oceans Canada; PSC = Pacific Salmon Commission). Sampling was not always continuous through the time periods specified.

Location	Instrument	Code	Distance from Steveston	Start Year	End Year	Measurement Frequency	Resolution	Accuracy (°C)	Scale	Agency
Hells Gate	Hand Held Spot	A	200	1941	1997	Daily	0.1–1	0.5–1	F&C	PSC
Hells Gate	Thermograph	B	200	1945	1971	Continuous	0.5	1	F	PSC
Hells Gate	Unidata Logger	C	200	1993	1995	Hourly	0.01	0.1	C	DFO
Qualark	Real Time Logger	D	165	1996	2006	Hourly	0.01	0.1	C	DFO
Hope	Unidata Logger	E	150	1994	1995	Hourly	0.01	0.1	C	DFO
Agassiz	Electronic Data Logger	F	100	1988	1998	Hourly	0.1	n/a	C	DFO
Mission	Vemco	G	70	2002	2002	Hourly	0.1	0.3	C	DFO
Whonnock	Hand Held Spot	H	65	1987	2006	Daily	0.1-1	n/a	F&C	PSC
Whonnock	Vemco	I	60	2003	2006	Hourly	0.1	0.3	C	DFO
Albion	Hand Held Spot	J	55	1983	1991	Daily	0.1-1	n/a	C	DFO
Patullo Bridge	Thermograph	K	20	1954	1970	Continuous	0.5	1	F	PSC
Patullo Bridge	Electronic Data Logger	M	20	1987	2000	Hourly	0.1	n/a	F&C	DFO
Annacis Island	Vemco	L	15	2002	2002	Hourly	0.1	0.2	C	DFO
Cottonwood	Hand Held Spot	M	5	1982	2006	Daily	0.1-1	n/a	C	PSC
Steveston	Vemco	N	0	2002	2002	Hourly	0.1	0.2	C	DFO

n/a = information not available.

Figure 1. Location of temperature recording sites in the lower Fraser River. Location codes are provided in Table 1.



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SITE COMPARISONS

We began with the assumption that the Hells Gate dataset, which was permanently relocated to Qualark in 1996 (See Brown et al. 1998), was the most complete and would be the framework and form the basis for comparison with measurements from all other downstream locations. Data from 1994 to 1998 collected at Hope and Hells Gate or Qualark (Brown et al. 1998) were compared, followed by comparisons with contemporaneous data from Agassiz (1996-1998) (Barnes and Walthers 1997, Brown et al. 1998, Barnes and Magnusson 2000). Data loggers deployed below Agassiz in 2002 at sites with previous temperature records (Table 1), provided estimates of diurnal temperature fluctuation and opportunities for further comparison with Qualark records. For instance temperatures at Whonnock (2003-2006) and Patullo Bridge (1995, 1997, 1999-00) were compared to Hells Gate/Qualark. All loggers were located as near as possible to the original thermograph locations within the limits of site access restrictions.

Temperature records from Patullo Bridge collected by the IPSFC, and then later by DFO, were our second most complete set of continuous data after Hells Gate. Mean daily and monthly temperature patterns from 1954–1970 and 1995, were compared between these sites. Comparisons with Qualark were made with 1997, 1999, and 2000 data.

Data Verification

After gathering data sources from different locations along the lower Fraser River, we compared the datasets among locations to determine the quality of the data. A separate graph for each year displaying all available temperature data was qualitatively evaluated for consistency with other sites. The results from site comparisons described above were also used to look for inconsistent patterns among locations. Data sources were ranked by year based on the five-point scaling system described below:

Rank 1: Included only continuous electronic temperature loggers located at Hells Gate, Hope, or Qualark. These data were verified either through proof of continuous calibration or corroborating temperature data.

Rank 2: Datasets collected using a thermograph or electronic logger downstream of Hope that were verified by another data source.

Rank 3: Temperature data that appeared accurate but where there was no evidence of continuous equipment calibration and they could not be verified with corroborating data. Many of the spot temperatures from Hells Gate fall within this category.

Rank 4: Spot data collected with low resolution instruments in locations of high diurnal fluctuation in temperature.

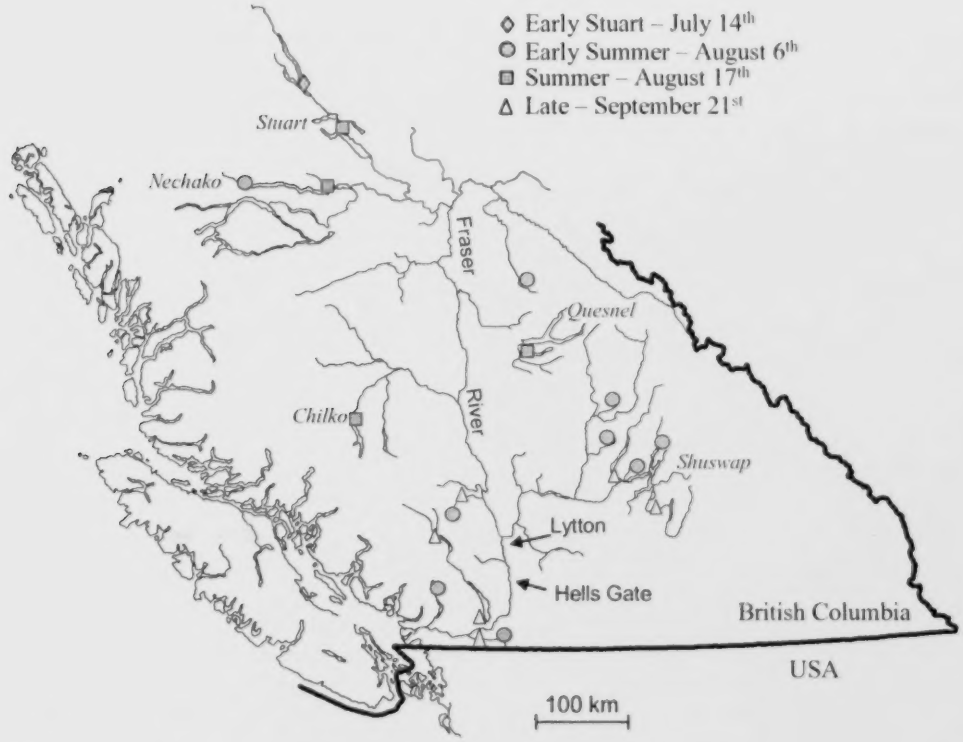
Rank 5: Datasets that failed to corroborate with temperature patterns from nearby sources or were systematically biased greater than 2. Data in this lowest ranking were of little value for our analysis.

Datasets with a rank of 4 or 5 were not used in the reconstruction, and the highest ranked source closest to Hells Gate was used in cases where more than one temperature dataset was available. Some data gaps were unavoidable but no data values were interpolated. Surrogate data (locations downstream of Hope) used to fill gaps were not adjusted for water velocity travel time or spatial trends in thermal heating.

ENVIRONMENTAL CONDITIONS AND SOCKEYE SALMON RUN TIMING

After reconstruction, the dataset spans 66 years of estimated temperature conditions experienced by four sockeye run-timing groups as they pass through Hells Gate. Fraser River sockeye salmon enter the river from late June through October in four distinct run-timing groups: Early Stuart (June–July), Early Summer (July–August), Summer (July–August), and Lates (August–October) (Figure 2). Run-timing information was based on the historic median passage date through Hells Gate from 1977 to 2006 (Ian Guthrie, Pacific Salmon Commission, 600-1155 Robson Street, Vancouver, BC by pers. comm.). An average temperature was calculated for each year during the 19-day period of peak passage through Hells Gate, centred on the historic median passage date for each group. The same procedure was used to calculate the mean and standard deviation of water discharge at Hells Gate for each run-timing group. Discharge data, based on the gauging station at Hope from 1912–2006, was provided by Water Survey of Canada, Environment Canada. We used the historic run timing periods to determine if each of the run timing groups were experiencing a significant change in thermal or discharge exposure over the 54 year period of continuous data only (1953 to 2006). Using only the contiguous data set avoids the problem of missing data and lack of corroborating data that exists prior to 1953.

Figure 2. Location of the major spawning grounds by run-timing group and their historic median passage date past Hells Gate in the Fraser River watershed.

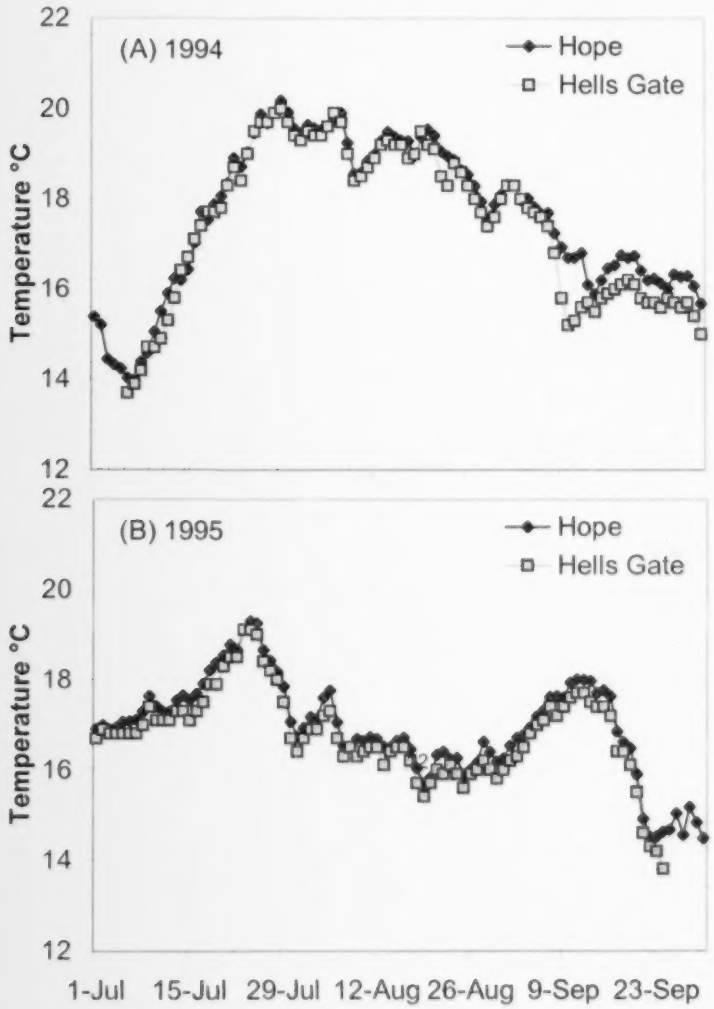


RESULTS

SITE COMPARISONS

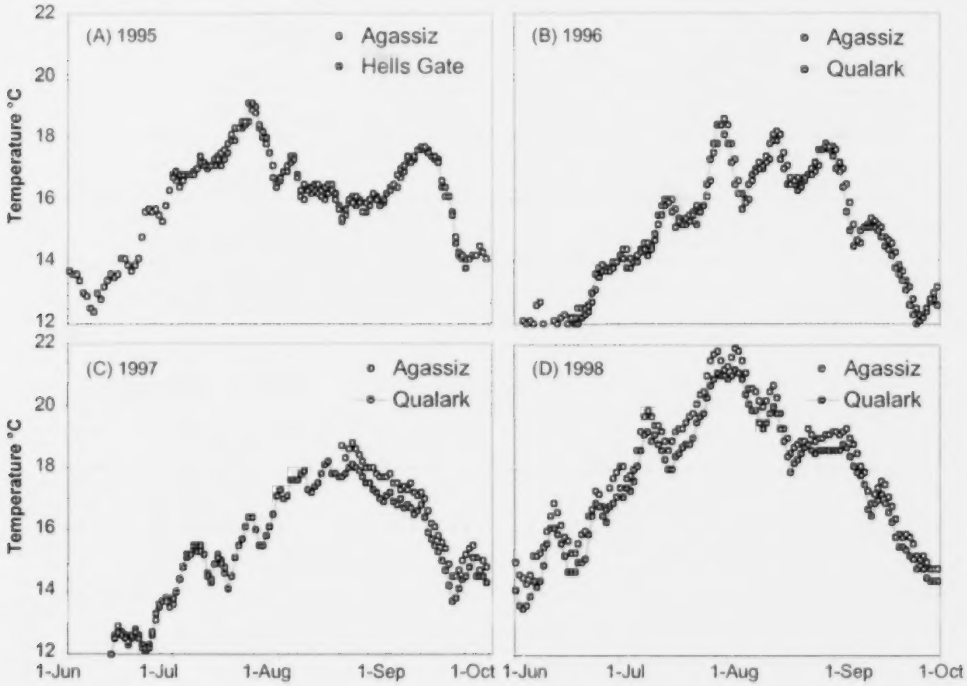
The daily mean temperature at Hells Gate was 0.3 °C lower on average than Hope for the years of 1994 and 1995 (Figure 3). The largest monthly temperature difference, occurring in September 1994, was 0.5 °C.

Figure 3. Daily mean temperatures on the Fraser River measured using a Unidata logger at Hells Gate and Hope in 1994 (A) and 1995 (B).



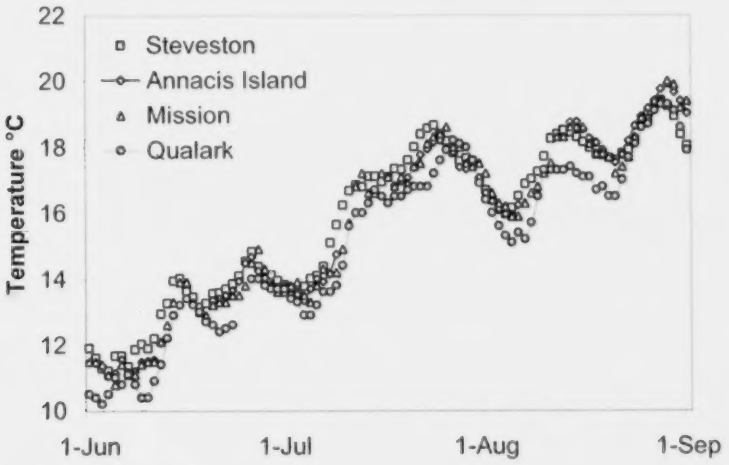
From 1995 to1998, temperatures in the Fraser River at Agassiz were in close agreement with those at Hells Gate and Qualark (Figure 4). Agassiz temperatures were the same as Hells Gate in 1995, and 0.2 °C, 0.3 °C, and 0.6 °C warmer than Qualark in successive summers. The absolute difference in daily mean temperature between the sites averaged by month was never greater than 0.7°C and temperature differences did not change as the summer progressed.

Figure 4. Daily mean water temperature in the summer at Hells Gate and Agassiz in 1995 (A) and Qualark and Agassiz from 1996 to 1998 (B–D). Measurements are based on a Unidata logger at Hells Gate, an electronic data logger at Agassiz, and a real-time logger at Qualark.



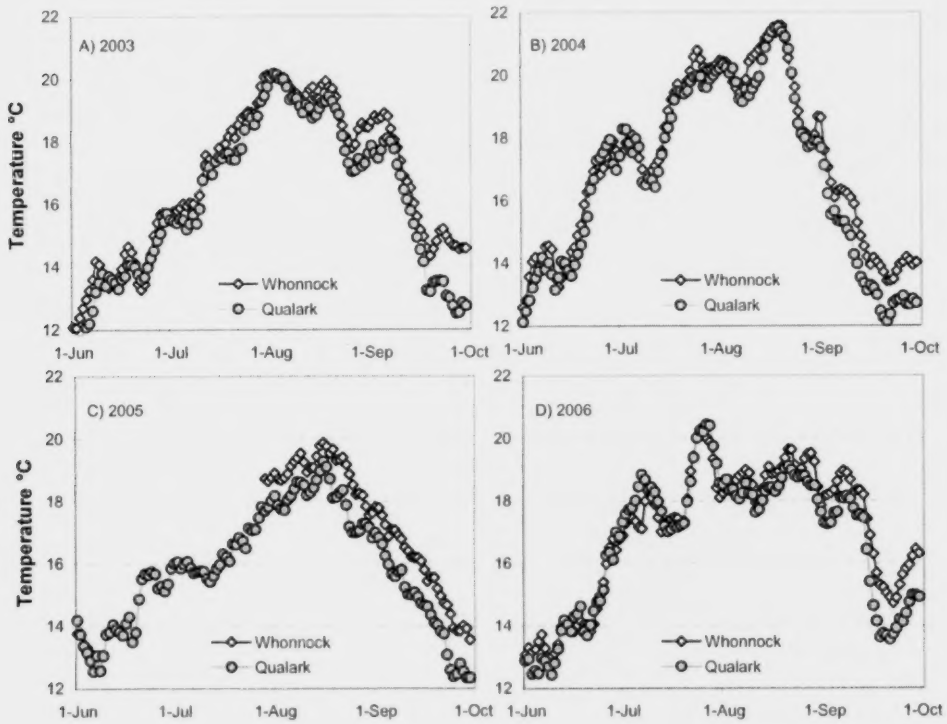
Mean daily temperature increased slightly from Qualark to the river mouth in 2002 (Figure 5). The monthly mean difference between Qualark and sites downstream was less than 1.0°C.

Figure 5. Daily mean water temperature in the summer of 2002 from four locations in the lower Fraser River: Steveston (0 km), Annacis Island (15 km), Mission (70 km), and Qualark (165 km).



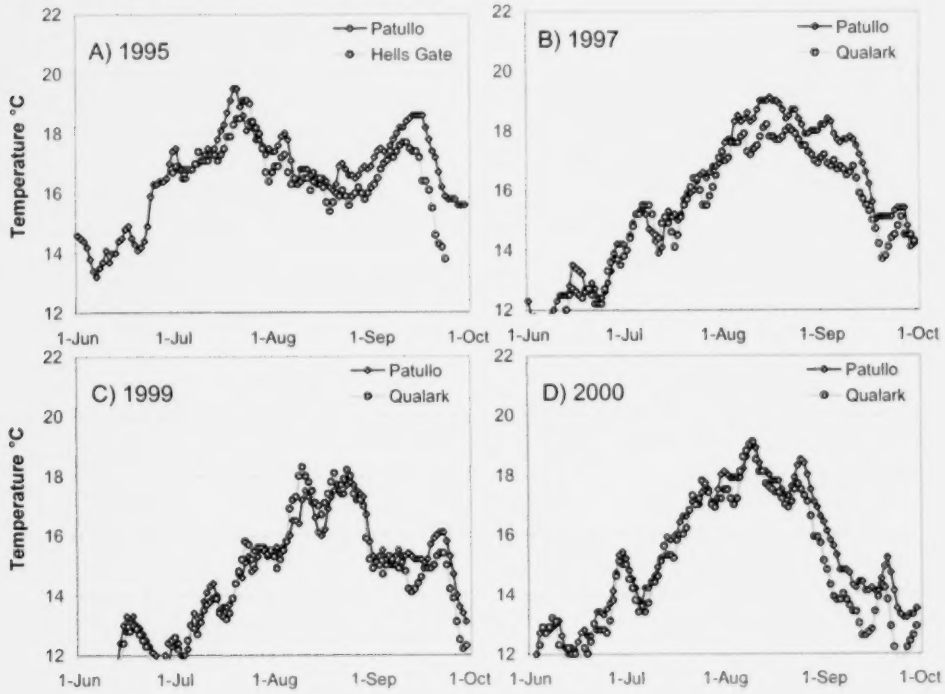
The Fraser River at Whonnock was on average 0.5–1.0 °C warmer than at Qualark (Figure 6). Differences in temperature between sites increased through the summer. The largest absolute difference in monthly mean temperature was 1.2 °C in September 2005.

Figure 6. Water temperature at Qualark and Whonnock in the summer of 2003 (A), 2004 (B), 2005 (C), and 2006 (D).



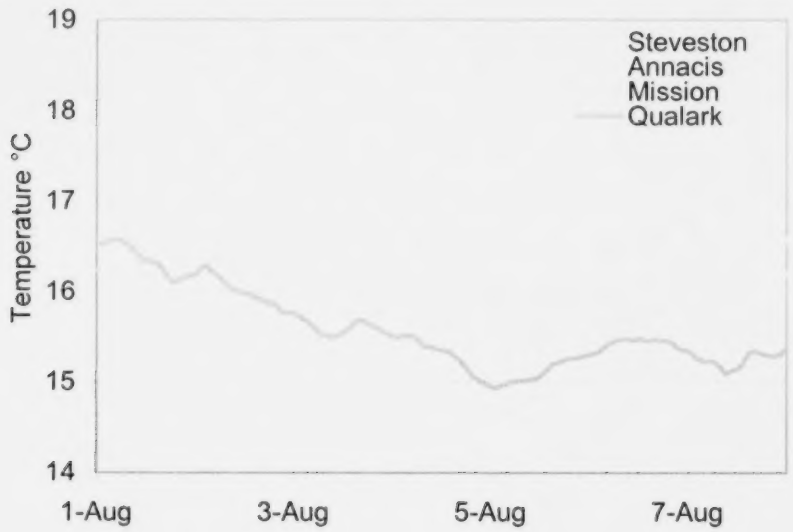
Annual average temperature at Patullo Bridge were 0.6 °C warmer than at Hells Gate in 1995, and 0.6 °C, 0.1 °C, and 0.5 °C warmer than at Qualark in 1997, 1999, and 2000, respectively (Figure 7). Differences in temperature between sites decreased from June to July then increase from July to September. The largest absolute difference in average monthly temperature occurred in September 2000 when waters were 1.2 °C warmer at Patullo Bridge than Qualark.

Figure 7. Summer water temperature at Hells Gate and Patullo Bridge in 1995 (A), and Qualark and Patullo Bridge in: 1997 (B), 1999 (C), and 2000 (D).



A single spot temperature recorded once a day did not always give an accurate reflection of the daily mean value based on the high diurnal fluctuation (Figure 8). The accuracy of the reading was dependent on the location, time of day, and date. Locations closer to the mouth of the Fraser River had the greatest daily temperature fluctuation (Figure 8).

Figure 8. An example of weakening diurnal patterns in water temperature from the Fraser mouth to locations upstream, data from the first week of August 2002. Measurements were taken hourly from four locations: Steveston (0 km), Annacis (15 km), and Mission (70 km), and Qualark (165 km).



Data Verification

The ranking of annual data quality for temperature measurements taken from different lower Fraser River sites from 1941 to 2006 are presented in Table 2. It was not possible to adequately verify Hells Gate temperature data collected prior to 1954 as little corroborating data were available, but data collected from 1954 to 1970 were verified by a close match to measurements from Patullo Bridge (Table 3), Data for verifying Hells Gate measurements between 1971 and 1980 were limited to 1978 and 1980. Between 1980 and 1995, the quantity of data available for verification increased but much of it was collected with a hand-held thermometer and of questionable quality. After 1995, with the installation of a permanent temperature station at Qualark, data quality, and later with the connection to the telephone system, speed of availability, improved.

Table 2. Available sources of water temperature data by location and year with their ranking (1 = best). Bold typeface indicates the temperature source used in the final dataset (see Appendix) for the temperature record in a given year. H.T. = hand-held thermometer, T.G. = thermograph, E.L. = electronic logger (i.e. Unidata logger, electronic logger, or Vemco)

	Hells Gate	Hells Gate	Hells Gate		Qualark	Hope	Agassiz	Agassiz		Mission	Whonnock	Whonnock		Albion	Patullo Br.	Patullo Br.		Annacis Is.	Cottonwood	Steveston
	H.T.	T.G.	E.L.		E.L.	E.L.	T.G.	E.L		E.L.	H.T.	E.L.		H.T.	T.G.	E.L.		E.L.	H.T.	E.L.
1941	**3**																			
1942	**3**																			
1943	**3**																			
1944	**3**																			
1945		**3**																		
1946																				
1947	**3**																			
1948	**3**																			
1949																				
1950		3																		
1951		**3**																		
1952		**3**																		
1953		**3**																		
1954		**2**													3					
1955		**2**													3					
1956		**2**													**3**					
1957		**2**													3					
1958	3	**2**													3					
1959		**2**					3								3					
1960		**2**													3					
1961		**2**													3					
1962	3	**2**													3					
1963		**2**													3					
1964		**2**													3					
1965		**2**													3					
1966	3	**2**													3					
1967		**2**													3					
1968		**2**													3					
1969		**2**													3					
1970	3	**2**													3					
1971	3	**3**																		
1972	**3**																			
1973	**3**																			
1974	**3**																			
1975	**3**																			
1976	**3**																			
1977	**3**																			
1978	**3**						3													
1979	**3**																			
1980	**3**						3													
1981	**3**																			
1982	**3**																		4	
1983	**3**													3					4	
1984	**3**													3					4	
1985	**3**													3					4	

	Hells Gate	Hells Gate	Hells Gate		Qualark	Hope	Agassiz	Agassiz		Mission	Whonnock	Whonnock		Albion	Patullo Br.	Patullo Br.		Annacis Is.	Cottonwood	Steveston
	H.T.	T.G.	E.L.		E.L.	E.L.	T.G.	E.L		E.L.	H.T.	E.L.		H.T.	T.G.	E.L.		E.L.	H.T.	E.L.
1986	**3**													3					4	
1987	**3**										4			3	3				4	
1988	5						**3**				4			3	5				4	
1989	4						**3**				4			3	3				5	
1990	4						4				4			3	**3**	5			4	
1991	5						**3**				4			3		5			5	
1992	5						4	**2**			4					2			5	
1993	5		**1**				5	2			5					2			5	
1994	3		**1**			1					4					2			5	
1995	3		**1**			1		2			4					2			4	
1996	3				**1**			2			4								4	
1997	3				**1**			2			4					2			4	
1998					**1**			2			4								4	
1999					**1**						4					2			4	
2000					**1**						4					2			4	
2001					**1**						4								4	
2002					**1**					2	4							2	4	2
2003					**1**						4	2							4	
2004					**1**						4	2							4	
2005					**1**						4	2							4	
2006					**1**						4	2							4	

1956 used Patullo Bridge values to supplement missing HG data

Table 3. The mean monthly water temperature (as the mean of daily mean temperature) of the Fraser River at Patullo Bridge (Pat.) for June–September from 1954–1970. Pat.- H.G. is the difference in the average of daily mean temperature between the two sites.

Year		June	July	August	September	Yearly Average
1954	Pat. Temp.	11.1	13.4	15.3	14.5	13.6
	Pat. - H.G.	-0.2	-0.8	-0.8	0.4	-0.3
1955	Pat. Temp.	11.1	14.0	15.1	14.6	13.7
	Pat. - H.G.	0.0	-0.3	-0.1	0.0	-0.1
1956	Pat. Temp.	10.9	15.2	18.2	15.8	15.0
	Pat. - H.G.	-0.1	-1.3		0.8	-0.2
1957	Pat. Temp.	13.7	15.5	16.6	16.0	15.4
	Pat. - H.G.	0.7	0.1	0.5	1.4	0.7
1958	Pat. Temp.	15.5	19.5	19.5	15.1	17.4
	Pat. - H.G.	0.5	0.8	1.1	1.1	0.9
1959	Pat. Temp.	12.4	15.9	16.4	13.4	14.5
	Pat. - H.G.	0.9	0.7	0.6	0.7	0.7
1960	Pat. Temp.	12.0	15.9	17.5	14.3	14.9
	Pat. - H.G.	0.4	0.9	0.9	1.7	1.0
1961	Pat. Temp.	14.5	17.7	19.7	14.9	16.7
	Pat. - H.G.	0.6	0.1	0.8	1.4	0.7
1962	Pat. Temp.	12.4	15.2	17.0	15.0	14.9
	Pat. - H.G.	0.4	0.4	0.7	1.4	0.7
1963	Pat. Temp.	13.1	15.7	18.3	17.1	16.0
	Pat. - H.G.	0.4	0.1	0.8	1.2	0.6
1964	Pat. Temp.	11.6	14.4	15.2	13.1	13.6
	Pat. - H.G.	0.4	0.0	-0.2	0.4	0.1
1965	Pat. Temp.	12.7	16.5	18.4	14.5	15.5
	Pat. - H.G.	1.1	0.4	0.6	1.3	0.9
1966	Pat. Temp.	11.9	14.8	16.6	15.5	14.7
	Pat. - H.G.	0.2	0.4	0.3	0.8	0.4
1967	Pat. Temp.	12.7	15.4	18.7	17.0	16.0
	Pat. - H.G.	0.9	0.4	0.8	1.6	0.9
1968	Pat. Temp.	11.8	15.0	17.0	15.1	14.7
	Pat. - H.G.	0.4	0.5	1.2	2.2	1.1
1969	Pat. Temp.	13.8	16.3	16.5	14.3	15.2
	Pat. - H.G.	-0.5	-0.1	0.5	1.1	0.2
1970	Pat. Temp.	13.3	17.3	18.2	14.4	15.8
	Pat. - H.G.	0.5	0.5	0.9	1.6	0.8
All Years	**Pat. Temp**	**12.6**	**15.8**	**17.3**	**15.0**	**15.2**
	SD	1.3	1.4	1.4	1.1	1.0
	Pat. - H.G.	**0.4**	**0.2**	**0.5**	**1.1**	**0.5**
	SD	0.4	0.6	0.5	0.6	0.4

Of the 8052 possible daily mean temperature values between June 1941 and September 30th 2006 we were able to compile 86% of the total, or 6909 values (Appendix 1). A mean annual Fraser River thermograph for the summer months was created based on data collected from 1941 to 2006 (Figure 9) and the hydrograph for June to September is based on 94 years (Figure 9).

ENVIRONMENTAL CONDITIONS AND SOCKEYE SALMON RUN TIMING

The four Fraser sockeye run-timing groups migrate during different thermal and hydrologic regimes (Figure 9, Table 4). Based on the few years available the 1940's were as warm as the most recent temperatures in the 1990's and 2000's. However, without a complete dataset it is not possible to accurately determine thermal trends prior to 1953. The temperatures experienced by all run-timing groups in the 1950's and 1960's were approximately 1 °C cooler than temperatures experienced in the 1990's and 2000's (Table 4).

Figure 9. Mean temperature and discharge ± 1 SD (dashed lines) of the Fraser River for June to September from 1941–2006. Boxes adjacent to x-axis represent the historic 19-day peak period of the run-timing groups at Hells Gate passage: from left to right Early Stuart (median date = July 14), Early Summer (median date = August 6), Summers (median date = August 17), Lates (median date = September 21).

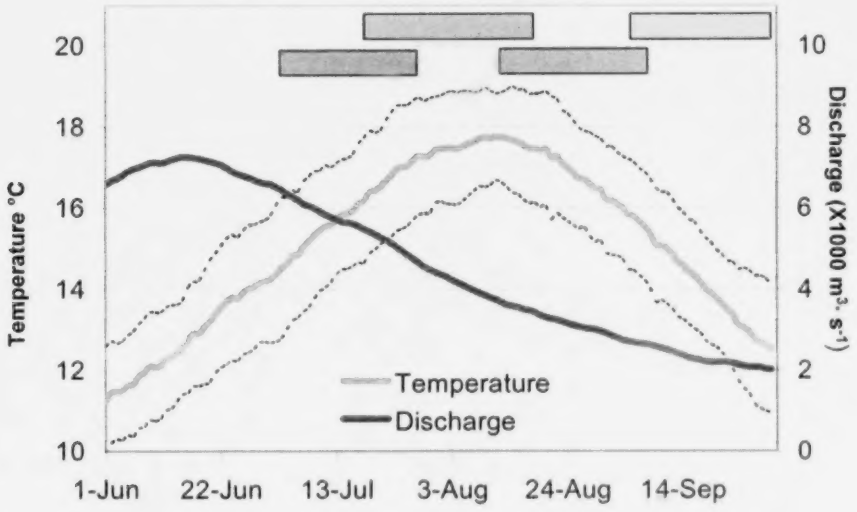


Table 4. Mean temperature (°C) and discharge* ($m^3 \cdot s^{-1}$) over a 19-day peak migration period (historic median date shown) at Hells Gate passage by decade from the 1940s–2000s for each sockeye run-timing group. SD = standard deviation.

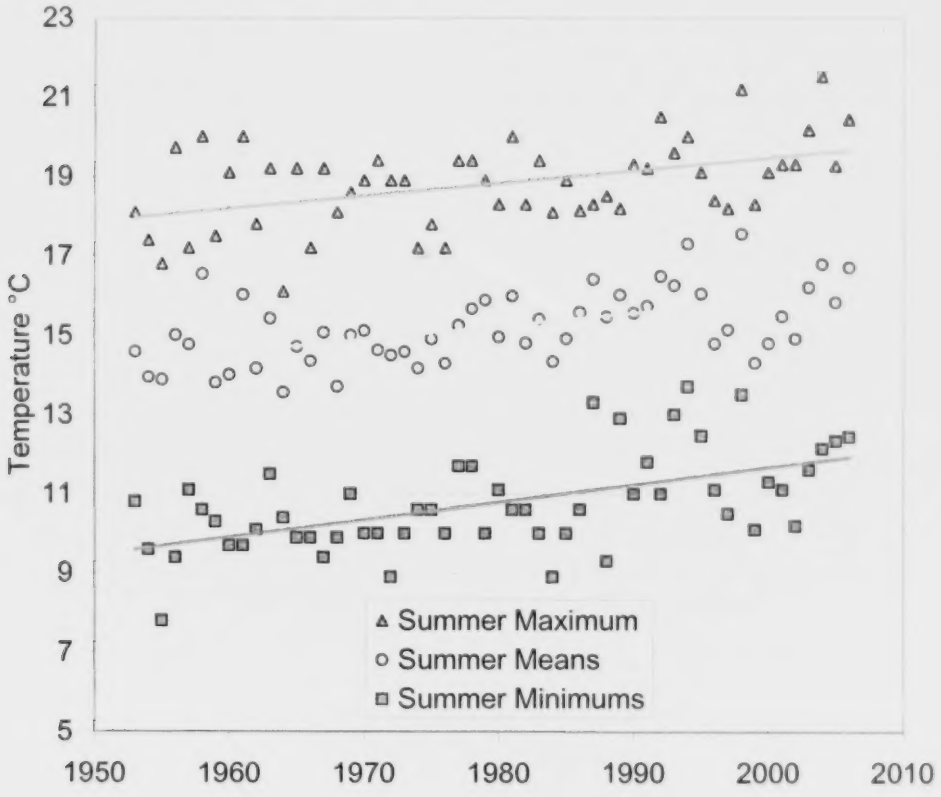
Mean 19-day Temperature and Discharge

		Early Stuart	Early Summer	Summer	Late
	Date of Hells Gate Passage	**July 14**	**August 6**	**August 17**	**September 21**
1940's					
	Temperature	16.7	17.3	16.9	13.5
	SD	1.7	1.0	1.2	0.7
	Discharge	4762	3713	3351	2074
	SD	849	558	638	319
1950's					
	Temperature	15.5	17.0	17.1	13.7
	SD	1.5	1.1	1.1	0.9
	Discharge	5860	3842	3266	2267
	SD	1409	817	617	783
1960's					
	Temperature	15.3	17.3	16.9	13.2
	SD	1.1	1.1	1.2	1.2
	Discharge	6187	4218	3705	2611
	SD	1348	806	557	458
1970's					
	Temperature	15.2	17.5	17.3	13.3
	SD	1.4	1.1	0.9	1.1
	Discharge	5903	4189	3569	2205
	SD	1442	1219	1199	634
1980's					
	Temperature	15.8	17.5	17.3	13.3
	SD	1.0	0.4	0.9	1.2
	Discharge	5142	3911	3316	2146
	SD	1143	836	610	715
1990's					
	Temperature	16.3	18.2	18.1	14.7
	SD	1.5	1.3	1.0	1.1
	Discharge	5731	4199	3496	1902
	SD	1871	1097	838	406
2000's					
	Temperature	16.6	18.2	18.3	13.8
	SD	1.0	1.2	1.0	0.8
	Discharge	5121	3573	2840	2095
	SD	1250	897	586	736
Historic Average					
	Temperture	15.8	17.5	17.4	13.6
	SD	1.4	1.1	1.1	1.1
	Maximum	19.6	20.4	20.2	16.3
	Discharge	5607	4014	3422	2228
	SD	1406	911	757	622

*Discharge values are based on the same years that were available for temperature averages. Temperature data was incomplete for the 1940's and 1950's datasets. See Appendix for further details.

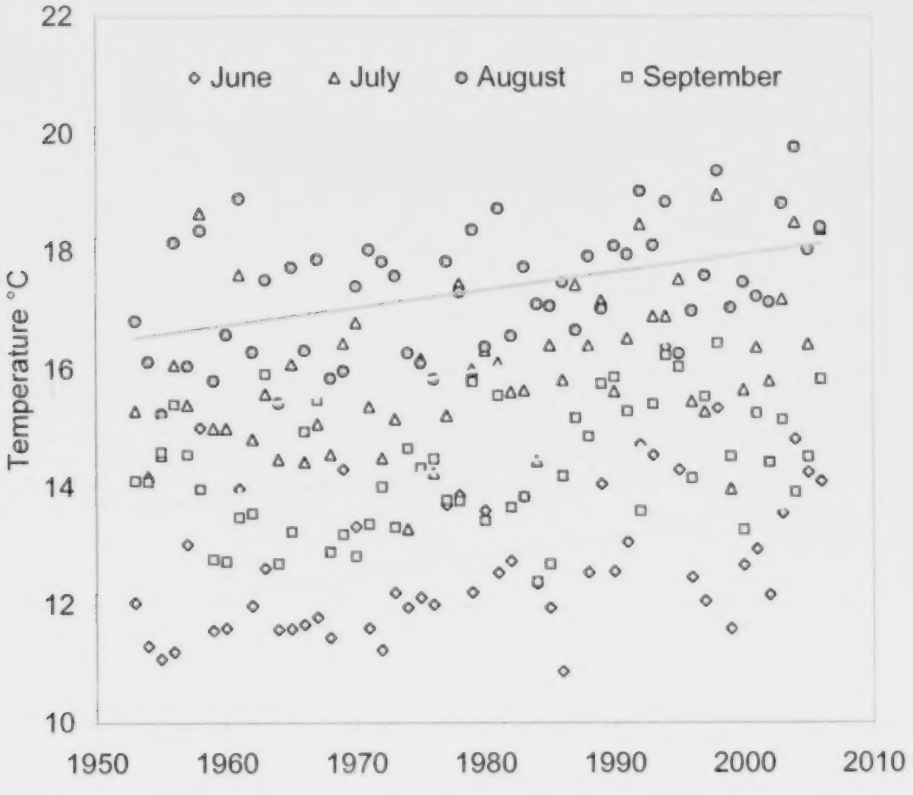
Since the mid-1950's Fraser River maximum, minimum, and mean annual summer temperature has increased (regressions; p<0.001; Figure 10). Minimum temperature has increased at the greatest rate of 1 °C in 23 years.

Figure 10. The daily mean (p<0.001, R^2 = 0.30, b=0.033), yearly maximum (p<0.001, R^2 = 0.20, b=0.032) and yearly minimum (p<0.001, R^2 = 0.30, b=0.044) for Fraser River water temperature during the summer (June 1st to Sept. 30) from 1953 to 2006 (n=54).



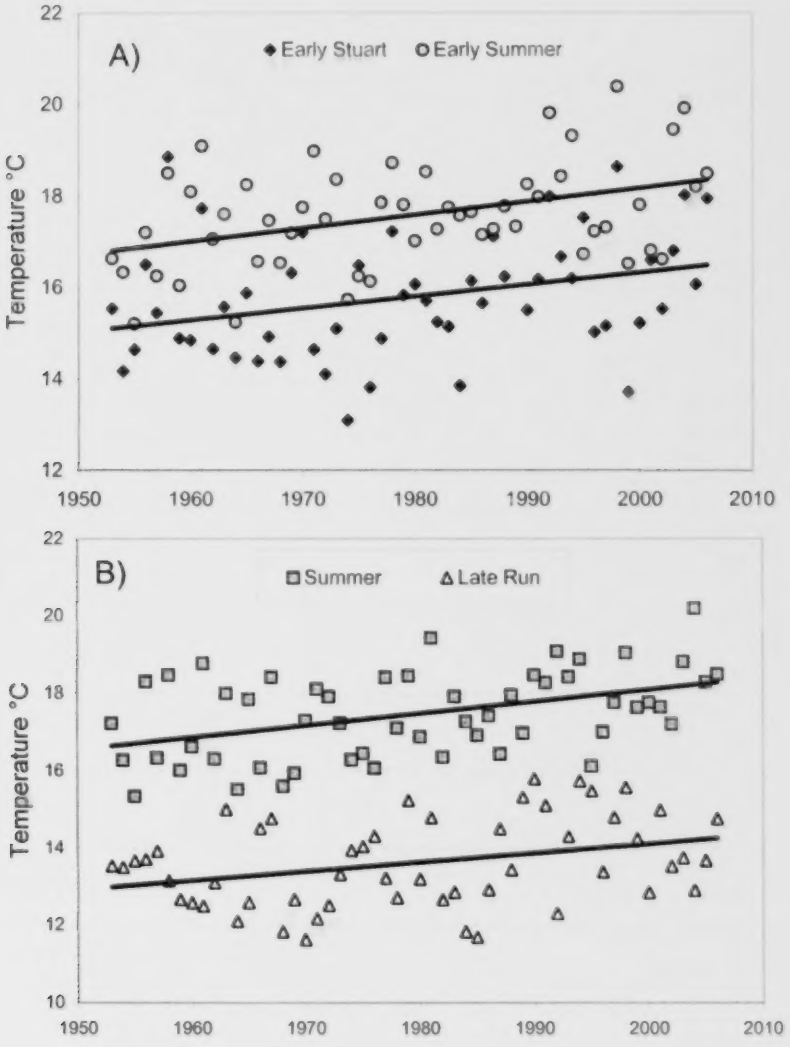
When partitioned by month, an increasing temperature trend remains (Figure 11) for all months. A 1 °C increase has occurred in 30 years in June and July, 33 years in August, and 40 years in September (Figure 11).

Figure 11. The mean monthly water temperature for each of the summer months, June (p=0.001, R^2 = 0.20, b=0.034) July (p=0.002, R^2 = 0.16, b=0.034), August (p=0.001, R^2 = 0.19, b=0.030) and September (p=0.006, R^2 = 0.12, b=0.025), has increased significantly from 1953 to 2006.



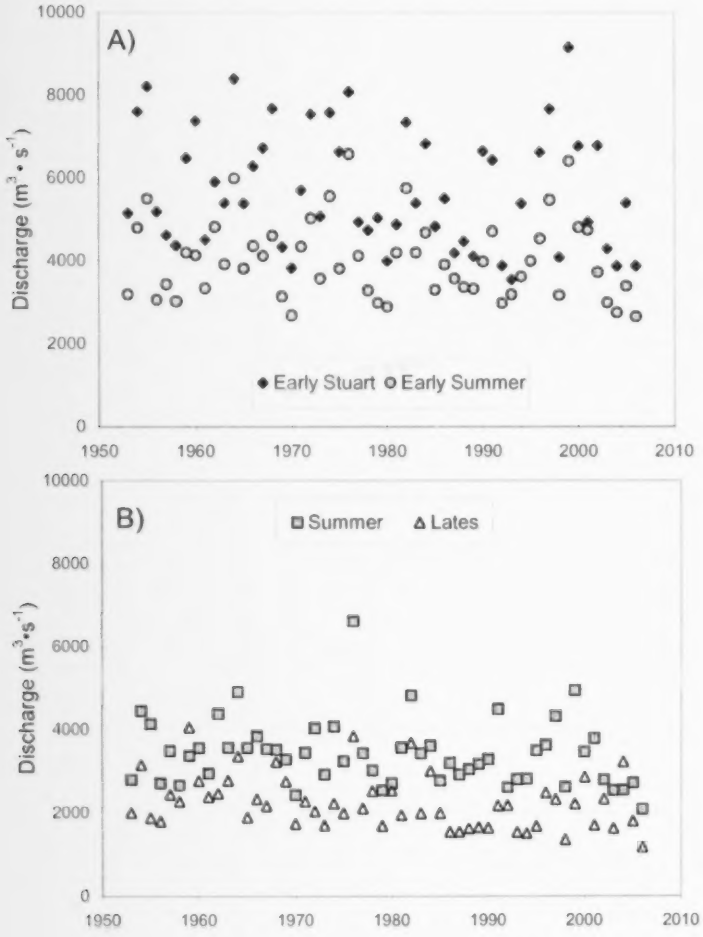
Consequently, the four Fraser River run timing groups have experienced warmer migration temperature in recent years particularly the Early Summer and Summer runs which generally experience the warmest temperature and where temperature has increased by 2°C since 1953 (Figure 12).

Figure 12. Water temperature (°C) experienced by four major sockeye run timing groups from 1953–2006: (A) Early Stuart (p=0.023, R^2 = 0.08, b=0.026) and Early Summer (p=0.002, R^2 = 0.15, b=0.029), and (B) Summer (p=0.001, R^2 = 0.18, b=0.031) and Lates (p=0.015, R^2 = 0.09, b=0.024). Each value represents the annual average temperature during a 19-day period, centred on the average migration date that each group passed Hells Gate.



Fraser River discharge varies considerably among years at Hells Gate particularly during July when the early run-timing groups enter the river. Unlike temperature, discharge has no annual trend (regression, $p>0.05$ for each run-timing group; Figure 13).

Figure 13. Water discharge ($m^3 \cdot s^{-1}$) experienced by the four major run-timing groups from 1941–2006 showing no significant trend (regressions $p>0.05$): (A) Early Stuart and Early Summer, and (B) Summer and Lates. Each value represents the average discharge during a 19-day period, centred on the historic average migration of each group past Hells Gate.



DISCUSSION

SITE COMPARISONS

The similarity between daily mean temperatures at Hells Gate and downstream sites as far away as Agassiz reflect the thermal stability of a river reach that receives relatively little tributary input and has a sufficient volume to surface area ratio to resist the influence of atmospheric parameters. In fact we found that temperature data obtained as far downstream as Steveston were not markedly different in annual pattern from Qualark and were on average less than 1 °C warmer. Between Patullo Bridge and Hells Gate from 1954 to 1970 the annual mean difference was 0.55 °C. Brown et al. (1998) found similarities among water temperatures collected at Hope, Hells Gate, and Lytton, the latter located upstream of Hells Gate, and 245 km upstream of Steveston.

Environmental variables such as air temperature, wind velocity, solar radiation and dew point are thought to have less influence on lower river temperatures (Hope) than upper watershed sites (Macdonald et al. 2000). However, increased flow particularly that associated with summer precipitation will reduce temperatures at Hope and presumably at other lower river locations. Downstream of Agassiz, the influence of several large rivers (Harrison, Chilliwack, and Pitt Rivers) can potentially contribute to the modest increases in Fraser River temperature as does the decrease in the mean gradient, velocity and depth of the river as it widens across a floodplain and receives increased exposure to sunlight. As the summer progressed, temperatures at sites downstream of Agassiz increasingly diverged from those at Hells Gate/Qualark. September temperatures generally differed the greatest in coincidence with slower water velocity. Tidal influence is partially responsible for an increase in diurnal temperature fluctuation near the mouth of the Fraser River. At high tide water velocity is reduced as the river spreads into shallow tidal channels and receives greater exposure to solar radiation.

The overall results from the site comparisons show that temperature measurements from all of the downstream sites are reasonable surrogates for Hells Gate temperature measurements. Given that mean temperatures and thermograph pattern were similar at these locations, it is reasonable that these datasets could be used to supplement missing data from Hells Gate and/or be used to verify Hells Gate temperature data.

Data Verification

Our reconstruction of the lower Fraser River temperature dataset provides the best available information allowing researchers to avoid using poor quality or incorrect data; however, the dataset has a number of limitations. First, the earliest years of the dataset are primarily composed of spot measurements. These measurements are obviously not equivalent to the daily average but will suffice as Hells Gate and Qualark temperatures have low diurnal variation (Gilhousen 1990). Second, the earlier data were collected with thermographs which had lower accuracy (±1°F) value than modern temperature loggers. Both thermographs and thermometers provided measurements in Fahrenheit, which were subject to rounding errors of 0.1 °C during the conversion to Celsius. Third, we used data from as far as Patullo (180 km from Hells Gate) to augment gaps in the Hells Gate dataset without correction despite a demonstrated (but modest) bias associated with distance and seasonality. In addition, early temperature collections did not anticipate the value of long-term comparative databases to assess subtle geographical and temporal differences in climate, to study atmospheric processes and products

or to develop ecosystem based, fish production models; yet, these tasks are inconceivable without high quality, consistent collections of long-term data. Thus we hope that this database begins a long-term effort to be improved with new sources of historic data and updated with contemporary values into the future.

ENVIRONMENTAL CONDITIONS AND SOCKEYE SALMON RUN TIMING

All populations of Fraser sockeye salmon are currently experiencing warmer summer migration temperatures in the lower Fraser than 50 years ago. The seasonal and monthly trends, which range from 0.025 to 0.044 °C per year, are considerable higher than previous estimates of 0.022 °C per year (Foreman et al. 2001). The long range impact of these warming temperatures on the upstream migratory success of different run timing group of sockeye salmon is uncertain but potentially very serious given that en route mortality and pre-spawning mortality are significantly and positively correlated to water temperature (Gilhousen 1990, Macdonald et al. 2000, Patterson et al. 2007).

The Early Stuart run-timing group are the first group to enter the Fraser River in late June. Historically they encounter the highest flows but generally lower temperatures than the later timed Early Summer and Summer run-timing groups. They ascend the Fraser River on the descending limb of the annual hydrograph but before the peak in thermograph. This timing has made them susceptible to en route mortality from both high temperatures and high discharge (Macdonald 2000, Macdonald et al. 2000). Annual mean daily temperature at present is 1.3 °C higher than 50 years ago, but there has been no detectable trend in the large annual variation in discharge levels experienced by Early Stuarts. Therefore, it appears that on average migration conditions are more difficult now than they were 50 years ago but only temperature is providing a consistent evolutionary force. Other researchers have predicted that additional energetic costs of swimming at higher temperatures will be offset by concomitant decline in water velocities (Rand and Hinch 1998). Thus far, this has not happened. If water temperatures continue to increase as predicted in the Fraser Basin (Morrison et al. 2002) then migration conditions will likely worsen for Early Stuarts. There is some evidence that salmon can adapt to a new thermal regime (Quinn and Adams 1996, Hendry et al. 1998), however it is unknown whether the current and forecasted pace of thermal increase will be slow enough to allow for adaptation to occur. Early Stuarts are currently squeezed between hydrographic and thermographic peaks, potentially restricting their ability to adapt to a new thermal regime by altering their migration timing alone. Moreover, the temperatures experienced by Early Stuart sockeye in the lower River do not represent the highest temperatures experienced during their migration. Typically, the temperatures in the Nechako and Stuart rivers where fish spend 3-5 days are several degrees higher than those in the lower Fraser River (Macdonald et al. 2000).

Early Summer sockeye salmon have experienced the highest migration temperatures in the lower Fraser river than other run timing groups (17.5 °C). Although there is compelling evidence that Early Summer sockeye are more adapted to swimming at higher water temperatures compared to Late run sockeye (Lee et al. 2001), they may be approaching the sustainable upper thermal limit for migration. In 5 of the past 15 years the majority of the run has experienced mean temperatures in excess of 19 °C. In a recent review by Hodgson and Quinn (2002) of 93 sockeye salmon populations, they found that no population had a mean migration temperature of greater than 18 °C. For those populations that migrate in rivers that do exceed 18 °C on average in the summer time the migration timing occurred either before or after the thermographic peak. They suggest that 19 °C may be a species-specific threshold for limiting migration. Applying the current trend in temperature, 1 °C per 35 years, to the Early Summer timing period creates a new mean value of 18.0 °C. It is unlikely, given the predicted

increase in summer temperatures that Early Summer run populations can continue to migrate at their present timing without episodic but frequent en route mortality. This situation is like more dire for those populations for which the lower Fraser river migration phase represents some of the cooler temperatures they experience during their entire migration (e.g. Upper Adams).

In recent years, the Summer run-timing group on the Fraser River has been experiencing warmer temperatures than it has historically experienced during upriver migration and at the highest rate of increase (1 °C per 32 years) among the run timing groups. They migrate during the warmest period of the year, but a brief delay in river migration timing would translate into a large decline in overall thermal exposure. The actual timing of river migration is likely bounded by spawning times (Hodgson and Quinn 2002). However, spawning timing of all Fraser stocks is positively correlated to the temperature regime on the spawning grounds (Brannon 1987). If winter incubation environments are increasing annually in concert with summer conditions some migration timing plasticity may exist. Furthermore, if a population has the historic facility to delay migration, timing could represent a means to avoid migration passages during the warmest periods of the year. For example, Okanagan sockeye salmon will delay migration to remain in cooler reservoirs if river temperatures exceed 21 °C (Hyatt et al. 2003). Some Fraser sockeye populations will not continue their migration following a forced delay (e.g. high water events) and time their freshwater migration to spawn and die shortly after arrival on the spawning grounds (Macdonald et al. 2000). Besides, this behavioural adaptation may be unrealistic for the many Fraser populations that do not have thermal refugia until they reach their natal rearing lakes.

Unlike other Fraser sockeye runs, the Late-run has historically delayed river entry for up to six weeks to enter the river in late September. However, in the past 12 years, despite a warming trend in the Fraser, this run has entered without a delay, exposing the majority of the fish to much higher freshwater temperatures and longer freshwater residency times (Cooke et al. 2004). Since 1995, the mean migration temperature (run timing centred on September 4th) has risen to 16.5 °C, a 3 °C increase from migrations before the1995 period which were centred on a timing peak of September 21st. The increase in temperatures associated with climate change in combination with a dramatic change in fish behaviour has resulted in mortality estimates exceeding 90% prior to spawning in some years (Cooke et al. 2004, English et al. 2005). Moreover, in recent years temperature increase in the lower Fraser River was greatest in September (~ 1.1 °C from Hells Gate to Patullo), as the Late-run enter the river. Therefore, a mortality model that uses Hells Gate or Qualark temperatures to represent Late run thermal exposure will underestimate the actual temperature exposure. In addition, the low discharge levels in September contribute to diurnal fluctuations in water temperature which may cause additional metabolic costs among the Late-run stocks.

CONCLUSIONS

We have reconstructed a long-term data set on water temperatures for the lower Fraser River during the time period that adult sockeye salmon migrate in river. All users of this water temperature data should take heed of the limitations with respect to data quality, resolution, and among site comparisons. The examination of thermal history for each of the four major run-timing groups clearly shows that migration conditions for Fraser sockeye salmon are worsening with respect to increasing temperatures and that future upstream migratory success of these runs will likely decline if current climate trends continue.

ACKNOWLEDGEMENTS

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REFERENCES

Barnes, D.P., and Magnusson, V.E. 2000. Water temperatures at selected sites in the Fraser River basin from 1997 to 1999. Can. Data Rep. Fish. Aquat. Sci. 1071:1-226.

Barnes, D.P., and Walthers, L.C. 1997. Water temperatures at selected sites in the Fraser River basin during the summer and fall of 1996. Can. Data Rep. Fish. Aquat. Sci. 1013:1-64.

Brannon, E.L. 1987. Mechanisms stabilizing salmonid fry emergence timing. *In* Sockeye salmon (*Oncorhynchus nerka*) population biology and future management. Edited by H.D. Smith, L. Margolis, and C.C. Wood. Can. Sp. Pub. Fish. Aquat. Sci. 96. pp. 120 - 124.

Brown, T.J., Barnes, D.P., and Walthers, L.C. 1998. Water temperature at selected sites in the Fraser Basin during the summer of 1995. Can. Data Rep. Fish. Aquat. Sci. 1039:1-50.

Cooke, S.J., Hinch, S.G., Farrell, A.P., Lapointe, M., Jones, S.R.M., Macdonald, J.S., Patterson, D.A., Healey, M.C., and Van Der Kraak, G. 2004. Abnormal migration timing and high enroute mortality of sockeye salmon in the Fraser River, British Columbia. Fish. Res. 29:22-33.

English, K.K., Koski, W.R., Sliwinski, C., Blakey, A., Cass, A.J., and Woodey, J.C. 2005. Migration timing and river survival of late-run Fraser River sockeye salmon estimated using radiotelemetry techniques. Trans. Am. Fish. Soc. 134:1342-1365.

Foreman, M.G.G., James, C.B., Quick, M.C., Hollemans, P., and Wiebe, E. 1997. Flow and temperature models for the Fraser and Thompson Rivers. Atmosphere-Ocean 35:109.

Fraser, J.A.C. 1995. Fraser River sockeye 1994: problems and discrepancies. PWGSC, Ottawa.

Gilhousen, P. 1990. Prespawning mortalities of sockeye salmon in the Fraser River system and possible causal factors. XXVI, IPSFC, Vancouver, BC.

Hendry, A.P., Hensleigh, J.E., and Reisenbichler, R.R. 1998. Incubation temperature, developmental biology, and the divergence of sockeye salmon (*Oncorhynchus nerka*) within Lake Washington. Can. Jour. Fish. Aquat. Sci. 55:1387-1349.

Hodgson, S., and Quinn, T.P. 2002. The timing of adult sockeye salmon migration into fresh water: adaptations by populations to prevailing thermal regimes. Can. Jour. Zoo. 80:542-555.

Hyatt, K.D., Stockwell, M.M., and Rankin, D.P. 2003. Impact and adaptation responses of Okanagan River sockeye salmon (*Oncorhynchus nerka*) to climate variation and change effects during freshwater migration: stock restoration and fisheries management implications. Can. Wat. Res. Jour. 28:689-713.

Lauzier, R., Brown, T.J., Williams, I.V., and Walthers, L.C. 1995. Water temperature at selected sites in the Fraser River basin during the summers of 1993 and 1994. Fisheries and Oceans Canada, West Vancouver, BC.

Lee, C.G., Farrell, A.P., Lotto, A.G., MacNutt, M.J., Hinch, S.G., and Healey, M.C. 2003. The effect of temperature on swimming performance and oxygen consumption in adult sockeye (*Oncorhynchus nerka*) and coho (*O. kisutch*) salmon stocks. The Jour. Exp. Bio. 206:3239-3251.

Macdonald, J.S. 2000. Mortality during the migration of Fraser River sockeye salmon (*Oncorhynchus nerka*): a study of the effect of ocean and river environmental conditions in 1997. Can. Tech. Rep. Fish. Aquat. Sci. 2315.

Macdonald, J.S., Foreman, M.G.G., Farrell, T., Williams, I.V., Grout, J., Cass, A., Woodey, J.C., Enzenhofer, H., Clarke, W.C., Houtman, R., Donaldson, E.M., and Barnes, D.P. 2000. The influence of extreme water temperatures on migrating Fraser River sockeye salmon (*Oncorhynchus nerka*) during the 1998 spawning season. Can. Tech. Rep. Fish. Aquat. Sci. 2326.

Meyer, J.L., Sale, M.J., Mulholland, P.J., and Poff, N.L. 1999. Impacts of climate change on aquatic ecosystem functioning and health. Jour. Am. Wat. Res. Asso. 35:1373-1386.

Morrison, J., Quick, M.C., and Foreman, M.G.C. 2002. Climate change in the Fraser River watershed: flow and temperature predictions. Jour. Hydrology 263:230-244.

Northcote, T.G., and Larkin, P.A. 1989. The Fraser River: a major salmonine production system. *In* Proceedings of the international large river symposium. Can. Sp. Pub. Fish. Aquat. Sci. 106. pp. 172-204.

Pankhurst, N.W., Purser, G.V.D.K.G.J., Thomas, P.M., and Forteath, G.N.R. 1996. Effect of holding temperature on ovulation, egg fertility, plasma levels of reproductive hormones and in vitro ovarian steroidogenesis in the rainbow trout (*Oncorhynchus mykiss).* Aquaculture 146:277-290.

Patterson, D.A., Skibo, K.M., Barnes, D., Macdonald, J.S., and Hill, J.A. 2007. The influence of water temperature on time to surface for adult sockeye salmon carcasses and the limitations in estimating salmon carcasses in the Fraser River, British Columbia. North Am. Jour. Fish. Mgmt. In press.

Pearse, P.H., and Larkin, P.A. 1992. Managing salmon in the Fraser: report to the Minister of Fisheries and Oceans on the Fraser River salmon investigation. Fisheries and Oceans Canada, Ottawa.

Quinn, T.P., and Adams, D.J. 1996. Environmental changes affecting the migratory timing of American shad and sockeye salmon. Ecol. 77:1151-1162.

Rand, P.S., and Hinch, S.G. 1998. Swim speeds and energy use of upriver-migrating sockeye salmon (*Oncorhynchus nerka*): simulating metabolic power and assessing risk of energy depletion. Can. Jour. Fish. Aquat. Sci. 55:1832-1841.

Sanders, J.E., Pilcher, K.S., and Fryer, J.L. 1978. Relation of water temperature to bacterial kidney disease in coho salmon (*Oncorhynchus kisutch*), sockeye salmon (*O. nerka*) and steelhead trout (*Salmo gairdneri*). Jour. Fish. Res. Board Can. 35:8.

Williams, B. 2005. 2004 Southern Salmon Fishery Post-season Review. Part one Fraser River Sockeye Report. http://www-comm.pac.dfo-mpo.gc.ca/publications/2004psr/default_e.htm.

APPENDIX

The Hells Gate temperature dataset from 1941 to 2006 after reconstructing it using temperature data from other sources along the Fraser River to supplement missing data and verify accuracy of the original dataset. Table 1 (above) provides a description of the measuring instruments and their resolution used to collect the data. Table 2 (above) indicates which temperature source was used when multiple datasets were available.

Date	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949
01-Jun										
02-Jun										
03-Jun										
04-Jun										
05-Jun						11.7				
06-Jun						11.7				
07-Jun						11.7				
08-Jun						11.7				
09-Jun						11.7				
10-Jun						11.7				
11-Jun						11.7				
12-Jun						11.7				
13-Jun						10.7				
14-Jun						12.0				
15-Jun						11.1				
16-Jun						11.1				
17-Jun						11.0				
18-Jun						10.9				
19-Jun						12.8				
20-Jun						12.9				
21-Jun						13.5				
22-Jun						13.4				
23-Jun						13.3				
24-Jun						12.8				
25-Jun						13.3				
26-Jun						13.3				
27-Jun						11.4				
28-Jun						11.8				
29-Jun						13.4				
30-Jun						14.0				
01-Jul					15.5	14.3				
02-Jul			18.0		15.0	14.4				
03-Jul		17.0	18.0	14.5	16.0	14.4		14.0		
04-Jul		17.0	18.0	14.0		14.7		14.5		
05-Jul		18.0	18.0	14.3	17.6	14.9		14.5		
06-Jul			18.0	14.0	16.0	15.2		14.5		
07-Jul		18.0	18.0	14.0	15.0	15.4		14.5		
08-Jul			18.0	14.3	15.0	16.0		14.5		
09-Jul			17.5	14.0	17.0	16.5		15.0		
10-Jul			17.5	13.7	17.0	16.8		15.0		
11-Jul			17.5	13.5		17.3		15.0		
12-Jul			17.0	13.5		17.3		14.5		
13-Jul			17.0	13.7	17.0	17.5		15.0		
14-Jul			17.5	14.3	15.0	17.8		15.5		
15-Jul			17.0	13.7	17.5	17.0		15.0		
16-Jul			17.0	14.0	17.0	16.4		14.5	16.3	
17-Jul		21.0	17.0		15.5	15.9		14.5	15.7	
18-Jul		21.0	16.5	14.5	17.0	16.0		15.0		
19-Jul		20.5	17.5	15.0	18.0	16.0		15.5	17.2	
20-Jul			17.5	14.5	18.0	16.2		16.0		
21-Jul			17.5	15.5	17.5	16.1		16.0	17.9	
22-Jul			18.0	15.3	18.0	16.1		16.5	18.3	
23-Jul		19.0		16.0	18.5	16.3		16.5		
24-Jul		18.0	18.0		19.0	16.0		16.5	15.7	
25-Jul		18.0	18.5		19.0	15.7		16.0	15.7	
26-Jul			18.0		19.0	16.7		16.0	15.7	
27-Jul			18.0	16.0	19.5	17.2		16.5	15.7	
28-Jul			18.0		19.0	17.8		16.5		
29-Jul			18.0	16.5	18.0	17.7		16.0		
30-Jul			18.0		18.0	16.7		16.0	16.5	
31-Jul			18.0	17.3	17.5	16.7		16.5	17.0	

Date	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949
01-Aug			18.0	17.0		16.7		16.5	16.9	
02-Aug			18.0	17.0	18.0	16.9		16.0		
03-Aug			18.0	16.5	18.0	16.7		16.5	17.1	
04-Aug			18.0		18.0	17.7		16.5		
05-Aug			18.5	15.5		18.1		16.5		
06-Aug			19.0		17.5	18.3		16.5		
07-Aug			19.0	16.0	17.5	18.9		16.5	16.5	
08-Aug			19.0		18.0	18.8		16.5	16.5	
09-Aug			19.0	16.3	18.0	18.8		16.5	16.5	
10-Aug			19.0		16.5	18.3		16.0	16.0	
11-Aug			19.0		17.0	18.3		16.5		
12-Aug			19.5	16.5				16.5		
13-Aug			19.5	16.0		18.8		16.5	16.6	
14-Aug			19.0	14.5	16.5	19.1		16.5	17.1	
15-Aug			19.0	15.5		18.9		16.5	17.5	
16-Aug			19.0	15.5		18.8		16.5		
17-Aug			19.0	15.5	14.6	18.2		16.5		
18-Aug			19.5	15.0		17.4		16.5	17.2	
19-Aug			19.5	15.0		17.2		16.5	17.0	
20-Aug			19.5			16.7		15.5		
21-Aug			19.5			16.9		15.0	16.7	
22-Aug			19.0			17.2		15.5		
23-Aug				16.0	15.5	16.9		15.5	16.5	
24-Aug			18.0	16.0				15.5	15.6	
25-Aug			17.5	15.0					15.1	
26-Aug			16.5	16.5	15.0	16.7		15.5		
27-Aug			16.5	16.3		16.7		16.0		
28-Aug			16.0	16.3	16.5			15.5		
29-Aug			15.5		16.5	16.7		16.5		
30-Aug			15.5			16.7		16.5		
31-Aug			16.0	15.3		15.8		16.0	14.0	
01-Sep			15.5	14.5		16.1		17.0		
02-Sep			15.5	14.5				17.0		
03-Sep			15.5					17.0		
04-Sep				14.0				17.5		
05-Sep								16.0		
06-Sep				15.3				14.5		
07-Sep				14.0	17.5			14.5		
08-Sep					15.0			14.0		
09-Sep				13.5				14.0		
10-Sep				14.3				14.0		
11-Sep								14.0		
12-Sep					16.5			14.5		
13-Sep										
14-Sep				13.8						
15-Sep				13.3				13.5		
16-Sep				13.5						
17-Sep				13.0	16.5					
18-Sep										
19-Sep				13.0						
20-Sep				12.5	12.5					
21-Sep				12.5						
22-Sep					13.0					
23-Sep				12.5						
24-Sep				12.0						
25-Sep				12.0	13.0					
26-Sep				12.5						
27-Sep					12.0					
28-Sep				12.0						
29-Sep					12.0					
30-Sep										

Date	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959
01-Jun		9.2		11.4	10.4	7.8	11.0	11.1	12.4	10.3
02-Jun		9.2		11.1	10.6	8.3	11.1	11.7	12.4	10.7
03-Jun		9.2		11.1	11.2	9.0	11.1	12.2	11.9	10.6
04-Jun		9.2		11.4	10.7	9.6	10.8	12.5	12.1	10.8
05-Jun		10.0		11.7	10.1	9.7	10.3	12.6	12.2	11.5
06-Jun		10.0		11.7	9.6	9.7	10.0	12.9	13.1	10.8
07-Jun		10.8		11.9	9.8	10.1	9.9	12.8	13.6	10.3
08-Jun		10.3		11.4	10.4	10.6	10.0	12.6	14.2	10.3
09-Jun		10.6		10.8	10.6	11.4	10.0	12.5	14.6	10.4
10-Jun		10.3		11.4	10.7	11.9	9.4	12.4	14.6	10.6
11-Jun		10.3		11.9	10.8	12.2	9.4	12.5	14.2	10.8
12-Jun		10.8		12.2	11.6	11.5	9.7	12.5	14.2	11.3
13-Jun		10.8		13.1	11.7	11.7	9.7	12.5	14.2	11.4
14-Jun		11.1		11.1	11.7	11.5	10.1	12.5	14.0	11.5
15-Jun		11.1		11.7	11.5	11.8	10.3	12.5	13.9	11.5
16-Jun		11.7		12.2	11.1	11.5	10.3	12.2	14.4	11.7
17-Jun		11.7		12.5	11.0	11.3	10.6	12.5	15.0	11.5
18-Jun		11.9		11.7	10.6	11.4	11.7	13.3	15.3	12.1
19-Jun		11.9		11.7	10.6	11.0	12.2	13.8	15.7	12.1
20-Jun		11.9		11.4	10.7	11.0	11.9	13.6	16.1	12.1
21-Jun		11.9		11.7	11.1	11.3	12.5	13.8	16.5	12.4
22-Jun		11.9		12.2	11.7	11.7	12.5	14.2	16.7	12.5
23-Jun		12.2		11.7	12.2	11.9	12.5	14.2	17.4	12.5
24-Jun		12.2		11.9	11.9	12.4	12.2	14.3	17.5	12.5
25-Jun		12.5		12.5	12.2	12.6	12.4	13.8	17.8	12.5
26-Jun		12.5		12.8	12.4	12.8	12.5	13.6	18.1	12.5
27-Jun		12.8		13.6	12.7	12.2	12.9	14.0	17.8	12.1
28-Jun		13.1		13.6	12.9	11.8	13.1	13.9	16.7	12.1
29-Jun		13.1		13.6	12.9	11.5	12.9	14.0	16.7	12.5
30-Jun		12.5		13.9	13.3	11.0	12.8	13.6	16.7	12.8
01-Jul		13.3		14.4	13.2	10.7	12.8	13.6	16.1	12.8
02-Jul		13.3		14.4	12.1	11.0	13.2	13.9	16.1	12.9
03-Jul		12.8		14.7	12.5	11.6	13.2	13.6	16.7	13.2
04-Jul		13.3		14.4	13.1	11.7	13.9	14.4	16.7	13.2
05-Jul		13.6		14.4	13.1	11.9	14.3	15.3	17.2	13.1
06-Jul		13.6		14.7	13.1	12.5	14.7	15.3	17.8	12.9
07-Jul		13.9		14.7	13.1	12.8	15.3	15.3	18.3	12.9
08-Jul		13.9		15.3	13.1	12.7	15.6	15.2	18.3	12.8
09-Jul		14.2		15.3	13.5	13.2	16.3	15.2	18.3	13.1
10-Jul		14.2		15.6	13.4	13.2	16.4	15.3	18.3	13.5
11-Jul		14.7		15.8	13.5	13.3	16.4	14.7	19.4	14.2
12-Jul		14.7		15.6	13.7	14.1	16.8	15.6	19.4	14.7
13-Jul		15.0		15.6	13.5	15.0	17.1	16.0	18.9	15.2
14-Jul		15.0		15.8	13.9	15.7	16.9	15.2	18.3	15.7
15-Jul		15.0		15.6	14.3	15.8		15.3	18.3	15.7
16-Jul		15.3		15.8	14.7	16.3		15.3	18.9	15.4
17-Jul		15.3		15.6	15.1	16.1		14.7	18.9	15.7
18-Jul		15.6		15.6	15.5	15.8		14.7	19.4	15.4
19-Jul		15.6		15.8	15.5	15.6		15.4	19.7	15.4
20-Jul		15.6		16.1	15.5	16.1		15.7	20.0	16.1
21-Jul		15.8		15.6	15.0	16.0		15.7	19.4	16.4
22-Jul		15.8		16.1	14.7	16.0		16.7	20.0	17.1
23-Jul		15.8		16.1	14.9	16.0		16.7	19.4	17.5
24-Jul		16.1		15.0	14.9	16.0	18.6	16.7	18.9	17.5
25-Jul		16.1		15.0	14.7	16.4	18.1	16.8	19.4	17.1
26-Jul		16.1		15.0	15.0	16.4	17.9	16.1	19.4	16.8
27-Jul		16.7		15.3	14.2	16.4	17.8	15.4	19.4	16.3
28-Jul		16.7		16.1	14.4	16.3	17.5	15.7	19.4	15.6
29-Jul		16.7		15.3	14.9	15.8	16.9	16.1	19.4	15.4
30-Jul		16.9		14.4	15.6	15.3	16.9	15.8	18.9	15.4
31-Jul		17.2		15.0	16.0	15.2	16.9	15.8	19.4	15.8

Date	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959
01-Aug		17.2		16.1	16.1	14.6	16.7	15.8	19.2	15.8
02-Aug		17.2		15.6	16.6	14.3	16.4	15.8	18.9	16.0
03-Aug		17.2		16.7	16.1	14.3	16.4	15.3	18.6	16.0
04-Aug		17.5		15.6	15.6	14.2	16.4	15.7	18.3	16.4
05-Aug		17.5		16.9	16.3	14.6	16.4	16.3	18.3	16.3
06-Aug		17.8		16.1	16.8	15.0	16.8	17.2	18.3	16.3
07-Aug		17.8		18.1	17.3	15.3	17.6	16.7	18.3	16.8
08-Aug		17.8		17.5	17.3	15.3	18.1	17.2	17.8	16.6
09-Aug		17.8	19.2	18.1	16.7	15.3	18.3	16.9	17.8	16.3
10-Aug		17.8	18.9	16.9	16.7	15.7	18.6	16.8	17.8	16.1
11-Aug		17.8	18.9	17.5	16.4	16.1	18.6	16.1	17.8	15.7
12-Aug		17.8	18.9	18.1	16.6	15.6	18.3	16.4	18.3	15.7
13-Aug	18.3	17.8	18.6	17.5	17.4	15.2	18.3	16.3	18.3	16.0
14-Aug	15.6	17.8	18.6	17.8	16.9	15.3	18.6	16.4	18.3	16.1
15-Aug	16.9	17.8	18.3	16.7	16.6	15.4	18.6	16.4	18.3	16.4
16-Aug	16.7	17.8	18.6	17.2	16.7	15.4	18.3	15.7	18.3	16.6
17-Aug	17.2	17.8	17.2	17.2	16.9	15.6	18.6	15.6	18.9	16.3
18-Aug	16.4	17.8	16.4	17.2	16.9	16.4	18.6	15.6	19.2	16.0
19-Aug	17.2	17.8	16.4	17.5	17.4	15.4	18.9	16.1	18.3	16.1
20-Aug	17.2	17.8	17.2	17.8	16.8	15.4	19.2	16.7	18.9	15.8
21-Aug	17.2	17.8	15.8	17.2	15.6	14.9	19.4	16.3	18.9	15.7
22-Aug	18.1	17.8	17.2	16.9	15.2	14.7	19.7	16.9	18.9	15.7
23-Aug	16.7	17.8	16.7	17.2	14.9	14.9	19.6	16.9	18.3	15.7
24-Aug	16.4	16.9	16.1	16.7	14.8	14.7	19.4	16.7	18.9	15.8
25-Aug	17.5	16.9	16.4	16.1	14.7	14.7		15.6	18.9	15.8
26-Aug	18.6	16.9	16.4	16.1	14.7	15.3		15.6	18.9	15.7
27-Aug	17.5	16.4	16.1	16.1	14.9	16.1		15.3	18.3	15.4
28-Aug	17.5	15.8	16.4	16.1	14.9	15.7		15.0	18.3	15.0
29-Aug	17.2	15.8	15.8	16.1	15.3	15.4		14.6	17.8	14.7
30-Aug	17.5	15.6	16.4	15.8	15.6	15.6		14.9	17.2	13.9
31-Aug	16.7	15.6	15.8	15.0	15.2	16.0	17.8	14.9	16.7	13.3
01-Sep	17.5	15.6	15.8	15.8	15.2	15.4	17.6	15.4	16.1	13.3
02-Sep	17.2	15.3	16.1	14.7	15.6	15.4	17.4	15.6	16.1	13.1
03-Sep	17.2	15.3	16.1	14.2	15.3	16.1	16.9	15.8	15.6	13.2
04-Sep	16.7	15.3	15.8	13.9	14.9	16.0	16.9	15.8	14.4	13.2
05-Sep	16.1	15.3	16.4	14.2	14.7	16.1	16.5	16.1	15.0	13.3
06-Sep	15.6	15.3	16.7	14.4	14.8	16.1	16.0	16.4	15.0	13.1
07-Sep	15.6	15.3	15.0	15.6	15.0	16.3	16.3	15.8		13.1
08-Sep	16.9	14.4	15.3	15.8	15.2	16.6	16.4	15.3	15.6	12.7
09-Sep	14.4	14.4	13.9	16.1	15.3	16.7	16.0	15.4	15.6	12.1
10-Sep	15.6	14.4	14.4	15.6	15.5	16.8	15.8	15.3	15.6	12.4
11-Sep	16.7	14.4	14.7	15.8	14.7	16.7	16.0	15.3	16.1	12.9
12-Sep	16.4	14.7	15.3	15.6	14.2	16.3	15.8	15.3	16.1	12.5
13-Sep	15.0	14.7	15.0	15.8	14.4	15.7	15.6	15.3	16.1	12.5
14-Sep	14.7	14.7	15.0	15.8	14.6	15.6	16.1	14.9	15.6	12.8
15-Sep	14.4	13.3	12.8	15.6	14.3	15.2	16.8	15.1	15.6	12.9
16-Sep	13.9	13.3	13.9	15.0	13.9	14.4	17.1	15.1	15.6	12.9
17-Sep	14.4	13.3	15.0	15.0	13.4	14.6	16.7	14.4	15.0	13.2
18-Sep	14.7	12.2	15.0	14.4	13.3	14.7	16.4	14.2	14.4	13.3
19-Sep	15.0	12.2	15.0	13.9	13.2	14.4	16.5	13.3	13.9	13.5
20-Sep	15.0	12.2	15.3	13.9	14.1	14.2	15.7	13.1	13.9	13.2
21-Sep	16.1	11.9	15.0	13.3	13.9	14.0	14.9	12.9	13.3	13.3
22-Sep	15.8	11.9	13.9	13.1	13.9	13.1	14.6	12.7	12.2	13.2
23-Sep	16.1	11.1	13.9	13.3	14.1	12.5	14.4	13.1	11.7	13.1
24-Sep	15.6	11.1	13.3	12.8	14.6	12.5	13.6	13.2	11.1	12.8
25-Sep	15.8	11.1	13.9	12.5	13.8	12.2	13.6	13.3	10.6	12.7
26-Sep	15.6	11.4	14.4	11.7	13.5	12.1	13.6	13.5	10.8	12.5
27-Sep	15.4	9.7	15.0	11.7	12.9	11.9	12.8	13.6	11.1	11.9
28-Sep	14.7	10.0	14.7	11.7	12.2	12.2	12.4	13.9	11.1	11.6
29-Sep	14.4	10.0	14.7	11.1	11.4	12.1	11.8	13.8	11.1	11.4
30-Sep	14.4	10.3	14.4	10.8	10.7	11.8	11.8	13.6	10.6	11.3

Date	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
01-Jun	9.7	11.1	10.8	11.8	10.7	9.9	9.9	9.4	10.4	11.0
02-Jun	10.0	11.5	10.6	11.8	10.7	10.0	9.9	10.0	10.6	11.4
03-Jun	9.9	11.9	10.6	11.8	10.6	9.9	10.1	9.9	10.3	11.9
04-Jun	10.0	12.5	10.3	11.8	10.8	10.0	11.0	9.9	10.6	12.4
05-Jun	10.1	13.1	10.1	11.8	11.3	10.3	10.7	10.6	11.0	12.9
06-Jun	10.6	13.2	10.3	11.5	11.1	10.3	11.7	11.0	10.7	13.1
07-Jun	10.7	13.3	10.8	11.9	10.8	10.3	11.8	11.0	10.3	13.2
08-Jun	10.6	13.2	11.4	11.9	10.4	10.7	11.9	10.8	10.4	13.2
09-Jun	11.1	13.2	11.7	11.8	10.6	11.1	12.1	11.4	11.0	13.6
10-Jun	11.5	12.6	11.4	11.5	11.1	11.4	12.1	11.0	11.7	14.2
11-Jun	11.9	12.4	11.4	12.1	11.9	11.5	11.5	10.8	11.8	14.4
12-Jun	12.1	12.8	11.4	12.5	11.4	11.7	11.3	10.8	11.8	14.7
13-Jun	11.9	13.1	10.8	12.4	11.4	11.5	11.5	11.0	11.8	15.0
14-Jun	11.9	13.6	11.0	12.5	11.9	11.5	11.4	11.1	11.4	15.0
15-Jun	12.5	13.8	11.8	12.4	12.4	11.3	11.3	11.7	11.0	14.7
16-Jun	12.4	14.2	12.5	12.2	12.5	10.8	11.7	11.4	10.7	15.1
17-Jun	11.8	14.2	12.5	12.8	11.9	11.3	12.2	11.8	11.1	15.7
18-Jun	11.9	14.9	13.1	13.5	11.9	12.5	12.4	12.4	11.7	15.8
19-Jun	11.8	15.0	13.1	13.9	11.5	12.6	12.6	12.4	12.1	16.4
20-Jun	11.1	15.3	12.8	13.8	11.4	12.8	12.6	12.6	11.7	16.3
21-Jun	11.0	15.1	12.6	13.6	11.8	12.9	12.4	12.5	11.9	16.0
22-Jun	11.5	15.3	12.5	13.5	11.9	12.5	11.8	12.5	11.8	16.0
23-Jun	12.2	15.3	12.6	13.1	11.9	12.2	11.7	13.1	12.4	16.0
24-Jun	12.5	15.3	12.9	13.5	12.5	12.2	11.4	13.6	12.4	15.7
25-Jun	12.4	15.4	13.2	13.3	12.5	12.5	11.7	13.6	12.6	15.1
26-Jun	12.4	15.6	13.8	13.1	11.8	12.6	11.8	13.5	12.4	14.3
27-Jun	12.9	15.7	13.6	12.9	11.9	12.5	12.2	13.3	11.9	13.9
28-Jun	13.1	15.6	13.5	13.1	11.9	12.9	12.6	13.3	11.7	13.9
29-Jun	13.1	15.4	13.1	13.3	12.2	12.9	12.2	13.5	12.1	13.8
30-Jun	13.3	15.3	13.1	13.3	12.5	12.9	12.2	13.5	11.8	14.2
01-Jul	13.6	15.3	12.6	14.4	12.8	12.8	12.2	12.8	11.4	14.6
02-Jul	13.6	15.3	12.4	14.9	12.8	13.5	12.2	12.8	11.9	15.3
03-Jul	13.2	15.4	12.5	15.1	12.8	14.2	12.2	12.8	12.8	15.3
04-Jul	13.1	15.7	12.8	15.6	13.3	15.2	12.2	13.1	13.3	15.2
05-Jul	13.5	15.8	12.8	15.6	13.9	16.1	13.3	13.1	13.6	15.0
06-Jul	13.9	15.8	12.8	16.1	14.2	16.0	13.3	13.6	13.9	15.2
07-Jul	14.4	16.4	12.8	16.1	14.4	16.1	13.3	14.4	14.2	15.8
08-Jul	14.6	16.7	13.9	16.1	14.4	16.1	13.9	14.4	14.4	16.6
09-Jul	14.6	16.9	15.0	16.4	14.7	15.6	13.3	13.9	14.4	16.9
10-Jul	14.3	17.2	15.6	16.1	14.4	15.0	13.9	13.9	15.0	16.9
11-Jul	14.3	17.4	16.1	15.6	15.0	15.0	13.3	14.2	15.3	16.8
12-Jul	14.1	17.1	16.1	14.7	14.9	15.0	13.9	14.4	15.0	16.6
13-Jul	14.7	17.5	16.1	14.7	14.7	15.6	13.9	14.7	14.7	15.8
14-Jul	14.7	18.1	15.6	14.7	14.6	15.7	13.9	15.6	14.4	16.0
15-Jul	14.9	18.2	15.6	14.4	14.4	16.1	14.4	15.6	13.9	15.7
16-Jul	15.2	18.2	15.0	14.2	14.6	16.3	14.4	16.1	13.3	15.6
17-Jul	15.4	18.1	15.0	15.0	14.7	16.3	15.0	16.1	13.9	15.8
18-Jul	15.4	18.6	14.4	16.1	14.3	16.4	15.6	16.1	13.9	16.0
19-Jul	15.4	18.6	13.9	16.1	13.9	16.1	16.1	15.8	14.4	16.4
20-Jul	15.7	18.9	14.4	16.1	14.2	16.0	15.6	15.6	13.9	16.8
21-Jul	15.8	19.2	14.4	16.1	14.6	16.0	15.0	15.0	14.2	17.1
22-Jul	15.6	18.9	14.4	15.6	14.3	16.1	15.6	15.3	15.0	17.1
23-Jul	15.4	19.1	14.4	16.1	14.4	16.1	15.6	15.6	15.6	17.8
24-Jul	15.2	18.9	15.0	15.6	15.0	16.4	15.0	16.4	15.0	18.6
25-Jul	15.2	18.3	15.6	15.6	15.3	17.2	15.0	15.8	15.0	17.8
26-Jul	15.3	18.3	16.1	15.6	15.3	17.9	15.0	16.1	15.6	16.8
27-Jul	15.4	18.6	17.2	15.6	15.0	17.7	15.6	17.2	16.1	17.8
28-Jul	15.7	18.5	15.6	15.6	14.9	17.8	16.1	16.7	16.7	17.9
29-Jul	16.7	18.1	16.7	16.1	14.9	17.8	16.1	17.2	16.7	16.9
30-Jul	17.7	18.1	17.2	16.4	15.7	18.1	16.1		16.9	16.7
31-Jul	18.2	18.6	17.2	16.7	16.0	18.6	16.1	17.8	16.7	16.9

Date	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
01-Aug	18.6	18.8	17.8	16.7	16.1	18.9	16.1	17.2	16.7	17.8
02-Aug	18.3	19.4	17.8	16.7	15.8	18.9	16.7	16.7	16.9	17.8
03-Aug	18.5	19.7	17.8	16.7	15.7	19.2	16.9	16.7	17.2	17.7
04-Aug	19.1	19.7		16.7	15.4	18.6	17.2	16.7	17.8	17.1
05-Aug	18.8	20.0	17.8	16.9	14.6	18.3	17.2	16.9	18.1	16.4
06-Aug	18.1	20.0	17.8	17.8	14.2	18.3	16.7	16.3	17.2	16.4
07-Aug	18.1	19.9	17.8	17.8	14.7	18.6	16.7	16.3	16.9	16.9
08-Aug	17.8	19.7	17.2	18.3	14.7	18.3	17.2	17.2	16.1	17.8
09-Aug	18.1	18.9	16.7	18.3	14.2	18.6	17.2	17.8	15.6	18.1
10-Aug	18.6	18.6	16.7	18.9	14.6	18.3	16.7	18.1	15.6	17.7
11-Aug	18.6	18.6	16.7	18.9	15.0	18.3	16.1	18.3	15.6	17.5
12-Aug	18.6	18.8	16.7	18.9	15.4	17.8	16.7	18.3	16.1	17.1
13-Aug	18.3	19.1	16.7	18.9	15.7	17.8	16.7	18.3	15.6	16.8
14-Aug	18.3	19.3	16.7	19.2	15.8	17.2	16.1	18.9	16.1	16.7
15-Aug	17.7	18.9	16.1	18.9	16.1	17.2	16.1	18.9	15.6	16.3
16-Aug	16.8	18.6	16.7	18.9	16.0	17.8	15.6	18.9	15.0	15.6
17-Aug	16.6	18.5	16.7	18.3	16.0	17.5	15.6	18.9	16.1	15.3
18-Aug	16.3	18.6	16.1	18.3	16.0	17.2	15.6	19.2	16.1	15.3
19-Aug	16.0	18.6	16.1	18.3	15.7	16.9	15.0	19.2	16.1	15.4
20-Aug	16.0	18.8	16.1	17.8	15.6	17.2	15.0	18.9	15.8	15.4
21-Aug	15.4	18.8	16.1	17.2	15.7	18.3	15.0	18.9	15.6	15.2
22-Aug	15.0	18.6	16.1	17.2	15.8	18.3	15.6	18.9	15.3	14.7
23-Aug	14.7	18.6	16.1	17.2	15.6	18.3	15.6	18.3	15.0	14.7
24-Aug	14.4	18.6	15.6	16.7	15.6	18.3	16.1	17.8	15.0	14.3
25-Aug	14.2	18.5	15.6	16.1	15.6	17.8	16.7	17.8	15.0	14.6
26-Aug	14.4	18.6	15.0	15.6	15.6	17.8	16.7	17.2	15.0	14.2
27-Aug	14.6	18.8	15.0	16.1	15.4	17.5	16.9	17.2	15.0	14.2
28-Aug	13.9	18.5	14.4	16.1	15.4	16.7	16.7	17.2	15.0	14.2
29-Aug	13.6	18.3	13.9	16.1	15.4	15.6	16.7	17.2	14.7	14.3
30-Aug	13.5	18.1	14.4	16.7	15.6	15.0	16.7	17.8	14.7	14.9
31-Aug	13.1	17.7	14.4	16.7	15.0	15.0	16.1	17.8	14.7	14.7
01-Sep	12.9	17.1	14.4	17.2	14.2	15.0	16.1	18.1	14.7	14.4
02-Sep	13.2	16.6	14.4	17.2	14.0	15.0	15.6	17.8	14.4	15.0
03-Sep	13.1	16.4	14.4	17.2	14.2	14.7	15.0	17.5	14.4	14.7
04-Sep	13.2	16.3	14.4	17.4	14.3	14.4	15.0	17.2	14.2	14.2
05-Sep	13.2	16.1	14.4	17.9	14.4	13.9	15.6	17.2	15.0	13.9
06-Sep	13.1	15.4	15.0	18.3	14.4	13.9	16.1	16.7	15.0	13.9
07-Sep	12.7	14.7	15.0	17.5	13.9	13.9	16.0	16.1	15.3	13.9
08-Sep	12.8	13.8	14.4	17.2	13.2	13.9	15.8	16.1	14.7	13.3
09-Sep	12.8	13.6	13.9	17.2	12.9	13.9	16.1	16.1	14.7	13.6
10-Sep	12.8	13.6	13.9	17.8	12.9	14.4	16.0	15.6	15.0	13.9
11-Sep	13.1	13.5	13.3	17.8	12.6	14.4	15.4	15.6	14.7	14.4
12-Sep	13.5	13.6	12.8	17.2	12.4	13.9	14.9	15.0	14.2	14.4
13-Sep	13.9	14.1	12.8	17.2	12.5	13.9	14.9	14.4	13.6	15.0
14-Sep	14.1	14.2	12.8	17.2	12.4	13.6	14.9	14.2	13.8	14.2
15-Sep	14.3	14.1	12.8	16.1	12.6	13.3	15.0	15.0	13.8	13.3
16-Sep	14.1	14.2	12.8	16.1	12.9	12.5	14.9	15.6	13.6	13.3
17-Sep	13.3	14.2	12.8	15.6	12.9	12.2	14.9	15.0	13.2	12.8
18-Sep	13.2	14.2	12.8	15.0	12.8	11.7	14.7	15.6	12.9	12.2
19-Sep	12.9	14.2	13.3	14.4	12.5	12.2	14.4	15.6	12.1	12.2
20-Sep	12.7	13.6	13.3	14.4	12.4	12.8	14.4	15.6	11.5	12.2
21-Sep	12.4	13.1	13.3	14.4	12.4	12.8	14.4	16.1	11.3	12.2
22-Sep	12.2	12.2	13.3	14.4	12.4	12.8	14.4	16.1	10.8	12.5
23-Sep	12.1	11.4	13.3	14.4	12.2	12.8	14.4	15.0	10.6	12.5
24-Sep	11.9	11.3	13.3	13.9	12.2	12.8	13.9	14.4	10.6	12.2
25-Sep	11.9	11.0	13.9	14.4	12.5		14.4	14.4	10.6	12.2
26-Sep	11.9	11.0	13.9	14.4	11.8	12.8	14.4	13.9	10.8	11.9
27-Sep	11.4	10.8	13.3	13.9	11.1	12.2	14.4	13.3	10.8	12.2
28-Sep	11.1	10.4	12.8	13.9	10.7	11.7	14.4	13.3	10.3	11.9
29-Sep	11.0	9.9	12.8	13.9	10.7	11.1	13.9	13.9	9.9	11.7
30-Sep	11.1	9.7	12.8	13.9	10.4	11.4	13.9	13.9	10.3	11.7

Date	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
01-Jun	10.6	10.0	11.1	10.0		12.5	10.0	11.7	12.1	10.6
02-Jun	11.9	10.0	11.1				10.0	11.7	12.9	
03-Jun	12.8	10.6	10.6		10.6	12.8	10.0	11.7	13.3	
04-Jun	12.8	10.8	10.6	10.6	10.6	12.2	10.0		14.3	11.7
05-Jun	13.1	11.1	10.0	10.6	10.6	12.2			14.4	11.7
06-Jun	12.8	11.1	10.0	10.6	10.6	11.7		12.8	14.7	11.1
07-Jun	12.8	11.7	10.6		10.6		11.1	13.3	14.2	11.1
08-Jun	12.5	11.4	11.1				12.2	13.3	14.4	10.0
09-Jun	12.5	11.4	11.1			10.6	12.8	13.3	14.2	
10-Jun	12.8	11.4	11.1		11.1	10.6	12.2	13.3	14.0	
11-Jun	12.2	11.1	11.1	11.1	11.7	11.1	12.2		13.9	11.7
12-Jun	12.5	11.1	11.7	11.1	11.7	11.7			13.8	11.7
13-Jun	11.7	11.1	11.1	11.1	11.7	12.2		12.8	12.8	11.1
14-Jun	11.9	11.1	10.6	11.7	11.7		11.7	12.8	12.8	11.7
15-Jun	12.2	11.1	10.6	11.7			12.2	12.8	12.8	11.7
16-Jun	12.5	11.1	10.6			12.2	11.7	14.4	12.8	
17-Jun	12.5	11.1			12.8	11.7	12.2	13.9	13.3	
18-Jun	13.2	10.8		12.2	12.8	11.7	12.2			12.2
19-Jun	14.2	11.7	10.6	12.2	12.8	11.7			13.3	12.8
20-Jun	15.0	11.4	11.1	12.8	12.8	12.2		15.0	13.3	12.8
21-Jun	15.3	11.9	11.1	12.8	12.8		12.8	15.6	13.9	12.8
22-Jun	15.4	12.8	11.1	13.3			12.8	15.6	13.9	13.3
23-Jun	15.6	12.8	11.7	13.3		12.8	12.8	15.6	13.9	
24-Jun	15.3	12.8			12.8	13.3	12.8	15.0		
25-Jun	14.7	12.8		13.9	12.8	12.8	12.2			12.8
26-Jun	14.4	12.8	12.2	13.9	12.8	12.8			14.4	13.3
27-Jun	14.4	12.8	12.8	13.9	12.8	12.8		13.9	14.4	13.9
28-Jun	14.2	12.8	12.8	13.3	12.8		12.8	13.9	15.0	13.9
29-Jun	13.9	12.5	12.8	13.3			13.9	14.4	15.6	14.4
30-Jun	13.9	12.8	12.8	12.8		12.8	13.3	14.4	15.6	
01-Jul	13.9	12.8	12.8	12.8		12.8	12.8	14.4	15.6	
02-Jul	13.9	12.8	13.3	12.8	12.2	13.3	13.3	14.4	15.6	13.9
03-Jul	14.2	13.1	12.8	13.3	12.2	13.3	13.3	13.9	16.1	13.3
04-Jul	15.0	13.3	12.8	13.3	12.2	13.9	13.9	13.9	16.7	13.3
05-Jul	15.6	13.3	13.3	13.3	12.8	15.0	12.8	13.9	16.1	13.3
06-Jul	15.8	13.3	13.3	13.9	12.2	15.8	12.8	13.9	16.1	13.3
07-Jul	16.4	12.2	14.4	13.9	12.2	16.1	13.3	13.9	16.7	14.4
08-Jul	16.9	12.2	14.4	13.9	12.2	16.7	12.8	13.9	17.2	15.6
09-Jul	16.7	12.8	14.4	13.9	12.2	16.7	12.8	14.4	17.8	15.6
10-Jul	16.7	13.3	13.9	13.9	12.8	17.2	13.3	14.4	17.2	15.6
11-Jul	16.9	13.9	14.4	14.4	12.8	17.2	13.9	15.0	16.7	15.6
12-Jul	16.7	13.6	13.9	14.4	13.3	16.7	13.3	15.6	16.7	15.6
13-Jul	16.4	13.9	13.9	14.4	13.3	17.2	12.8	15.6	17.2	15.0
14-Jul	16.7	14.4	13.9	15.0	13.9	17.2	12.8	15.6	17.8	15.0
15-Jul	16.7	14.4	13.9	15.6	13.9	17.2	12.8	16.1	17.6	15.0
16-Jul	17.2	14.4	13.9	15.6	13.9	17.2	13.3	16.1	17.4	15.0
17-Jul	17.5	15.0	13.9	15.6	13.9	17.2	13.9	16.1	17.2	15.6
18-Jul	18.3	15.0	14.4	15.6	13.3	16.1	14.4	15.0	17.2	16.1
19-Jul	18.9	16.7	13.9	16.1	13.3	16.1	15.0	15.0	17.2	17.2
20-Jul	18.9	17.2	13.9	16.7	13.3	16.1	15.6	14.4	17.2	17.8
21-Jul	18.3	17.2	14.4	16.7	12.8	16.1	15.6	15.0	17.8	18.3
22-Jul	17.8	17.5	14.7	17.2	13.3	15.6	15.6	14.4	17.8	18.3
23-Jul	18.3	17.8	15.0	16.7	13.3	15.6	15.6	14.4	18.3	18.3
24-Jul	17.8	18.1	15.6	16.1	13.3	16.1	16.1	15.0	18.3	17.8
25-Jul	17.2	17.8	16.1	16.1	13.9	16.7	16.1	15.6	18.3	17.2
26-Jul	16.9	17.8	16.1	16.1	13.9	16.7	16.1	16.1	18.9	17.2
27-Jul	17.2	17.8	16.1	16.7	13.9	17.2	15.6	16.7	18.9	17.8
28-Jul	17.2	18.3	16.1	17.2	14.4	17.8	15.6	17.2	18.9	16.7
29-Jul	17.2	18.3	16.4		14.4	17.2	15.6	17.2	18.9	16.7
30-Jul	16.7	18.9	16.4		14.4	16.7	15.0	17.2	18.9	17.2
31-Jul	16.4	19.2	16.7	18.3	15.0	16.7	15.6	17.2	18.9	18.3

Date	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
01-Aug	17.2	19.2	17.2	18.3	15.6	16.1	15.0	17.8	18.9	18.3
02-Aug	17.5	19.2	17.2	18.3	15.6	16.1	15.6	17.8	18.9	18.9
03-Aug	18.3	19.4	17.2	18.9	15.8	15.6	15.6	17.8	18.9	18.9
04-Aug	18.3	18.9	17.2	18.9	16.4	15.6	16.1	17.2	18.9	17.8
05-Aug	18.3	18.9	17.5		16.7	16.1	16.7	17.2	18.9	17.8
06-Aug	18.6	18.9	17.8		16.7	16.1	16.1	17.2	18.9	17.2
07-Aug	18.6	18.3	17.8	17.8	16.7	15.6	16.7	17.2	18.9	16.7
08-Aug	18.3	18.9	18.9	18.3	16.4	15.6	16.1	17.8	18.9	17.8
09-Aug	18.6	19.4	18.9	18.3	16.1	16.1	16.7	18.3	19.4	17.2
10-Aug	18.3	19.4	18.3	18.3	16.1	16.1	16.7	18.3	19.4	17.8
11-Aug	18.3	19.4	18.3	18.3	16.1	16.7	17.2	18.3	18.9	17.8
12-Aug	18.3	19.4	18.3			16.1	17.2	18.3	17.8	18.3
13-Aug	17.2	19.4	17.8	18.9	15.6	15.6	16.7	18.9	17.8	18.3
14-Aug	16.7	18.9	17.2	18.9	15.6	16.1	16.7	19.4	17.8	18.3
15-Aug	17.2	18.3	17.2		15.6	16.7	15.6	18.9	17.8	18.3
16-Aug	16.7	18.6	17.2		16.1	16.7	16.7	18.3	17.2	18.3
17-Aug	16.7	17.8	17.2	17.2	16.1	16.7	16.1	18.3	17.2	18.3
18-Aug	16.7	17.8	17.2	16.7	16.7	16.7	16.1	18.3	16.7	18.9
19-Aug	16.1	17.8	17.2	15.6	17.2	17.2	16.7	18.9	15.6	18.9
20-Aug	16.1	17.8	17.8	15.6	16.9	17.2	16.1	18.9	16.1	18.9
21-Aug	16.1	16.9	17.8	15.0		17.2	15.6	18.9	15.8	18.9
22-Aug	16.7	17.2	17.8		16.9	17.2	15.6	18.3	15.6	18.9
23-Aug	17.2	16.7	18.3		16.7	16.7	15.0	18.3	15.6	18.9
24-Aug	17.8	16.9	18.3	15.6		16.1	15.0	18.3	16.1	18.9
25-Aug	17.8	16.7	18.3			16.1	15.0	17.8	15.6	18.9
26-Aug	17.8	16.7	18.3		16.1	15.6	14.4	17.2	15.6	18.9
27-Aug	17.8	16.4	18.3		16.1	15.6	14.4	16.7	15.0	18.9
28-Aug	17.2	16.1	18.3		16.1	15.0	14.4	16.7	15.3	18.9
29-Aug	16.7	16.7	18.3		16.1	15.0	15.0	16.1	15.6	18.9
30-Aug	16.4	16.7	17.8		16.7	15.0	15.0	15.6	16.7	18.3
31-Aug	16.1	16.1			16.7	15.0	15.0	15.6	16.7	18.3
01-Sep	16.1	16.1	17.2		16.1	15.0	15.6	15.0	16.7	18.1
02-Sep	16.7	15.8	16.7		16.1	15.0	15.6	15.6	16.7	17.8
03-Sep	16.1	15.8	16.7		16.1	15.0	15.0	15.0	16.7	17.5
04-Sep	15.6	16.1	17.2		16.1	15.0	15.0	15.6	15.6	17.2
05-Sep	15.6	15.8	17.2		16.1	15.0	15.6	15.0	15.6	17.2
06-Sep	15.0	15.6	16.7		16.1	15.0	15.0	14.4	15.0	16.7
07-Sep	14.4	15.3	16.7		16.1	15.6	14.4	14.4	15.6	16.7
08-Sep	14.4	15.6	16.1		16.1	15.6	13.9	14.4	15.0	16.3
09-Sep	13.9	15.0	16.1		15.6	13.9	13.3	14.4	15.0	15.9
10-Sep	13.3	14.4	16.1		15.6	13.9	13.9	14.3	15.0	15.6
11-Sep	12.8	14.2	15.6		15.0	13.9		14.1	14.4	15.6
12-Sep	12.2	15.0	15.0		13.6	13.9		13.9	14.4	15.6
13-Sep	12.2	12.8	15.0		13.9	14.4	13.9	13.9	13.9	14.4
14-Sep	11.7	12.8	15.0		13.9	14.4	14.4	14.4	13.7	15.0
15-Sep	12.2	12.8	15.6		13.9	14.4	14.4	14.4	13.5	15.6
16-Sep	11.7	12.2	15.0		13.9	15.0	14.4	13.9	13.3	16.1
17-Sep	12.2	12.2	14.4	13.3	13.9	14.4	14.4	13.9	12.8	15.6
18-Sep	12.8	11.7	14.4	13.3	13.9	12.8		13.9	12.8	15.6
19-Sep	12.8	11.7	13.9	13.3	15.0	13.9		13.9	12.8	15.6
20-Sep	12.5	11.7	13.9	13.3	14.2	13.9	13.9	13.9	12.8	15.6
21-Sep	12.5	12.2	12.2	13.3	13.9	13.9	13.9	13.3	12.4	16.1
22-Sep	12.2	12.5	12.2	13.3	14.4	13.3	14.4	13.3	12.0	15.6
23-Sep	11.7	12.2	12.2	13.9	14.2	13.9	14.4	13.3	11.7	15.6
24-Sep	11.1	12.2	11.7	13.3	14.2	13.9	14.4	12.8	12.2	15.0
25-Sep	11.1	12.2	11.1	13.3	14.4	14.4		12.8	12.2	14.4
26-Sep	10.6	12.2	10.0	13.3	14.2	13.9		12.2	12.2	15.0
27-Sep	10.0	11.7	9.4	12.8	13.6	13.9	14.4	11.7	12.2	15.0
28-Sep	10.0	11.4	8.9	12.8	13.3	14.4	14.4	11.7	12.2	15.0
29-Sep	10.6	11.1	8.9	13.9	13.3	13.9	14.4	11.7	12.2	14.4
30-Sep	10.6	10.6	8.9	13.3	12.8	13.9	14.4	12.2	12.2	13.9

Date	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
01-Jun	11.5	10.6	11.7	13.9	10.6		10.7		11.3	12.9
02-Jun	11.5	12.2	11.7	13.9			11.1		11.3	13.1
03-Jun	11.5	12.2	11.7			12.2	10.9		11.4	13.3
04-Jun	11.1	11.7	11.7		11.1	12.2	10.6		9.4	13.5
05-Jun	11.1	12.2			11.1	11.7	11.0		9.3	13.3
06-Jun	11.3				11.1	11.7			9.6	13.1
07-Jun	11.8		11.1	13.9	11.7	11.7			10.0	13.5
08-Jun	12.4	11.7	10.6	13.3					9.9	14.6
09-Jun	12.6	11.7	10.6	13.3					10.1	14.2
10-Jun	12.8	11.7	10.6	12.8		11.1			10.4	13.8
11-Jun	13.1	11.7	11.7			11.1			10.1	14.2
12-Jun	13.6	12.2				11.7			10.4	13.9
13-Jun	14.2			12.8	12.8	11.7			11.0	14.2
14-Jun	14.3		13.3	13.3	12.8	11.7			11.0	14.2
15-Jun	14.0	12.8	13.3	13.9	12.8				11.4	14.6
16-Jun	14.3	12.8	13.3	13.9	12.2				13.1	14.3
17-Jun	14.3	12.8	12.8	13.9	12.2				14.6	14.3
18-Jun	14.4	12.8	12.8		12.2	11.7			14.7	13.9
19-Jun	14.6	12.8			12.8				15.4	13.2
20-Jun	15.3			13.9		12.8			15.3	13.1
21-Jun	15.6		13.3	13.3					15.3	13.5
22-Jun	15.3	12.8	13.3	13.3					15.0	13.8
23-Jun	15.0	12.8	13.9	13.9					14.7	14.0
24-Jun	14.7	12.8	13.9	13.9					14.4	14.2
25-Jun	14.9	13.3	13.9		13.3	11.7			14.0	15.0
26-Jun	14.6	14.4			13.9				14.3	15.0
27-Jun	14.4			14.4	13.9	12.8			14.9	15.6
28-Jun	14.4		14.4	15.0	13.3				14.3	15.3
29-Jun	14.6	13.9	15.0	15.0	12.2	13.3			14.9	15.1
30-Jun	14.6	13.9	15.6	15.0					14.7	14.7
01-Jul	14.4	14.4	15.6						14.6	15.1
02-Jul	15.0	14.4	15.6			13.9			14.9	15.7
03-Jul	15.6	15.0	15.6		12.2	14.4		18.3	15.3	15.9
04-Jul	15.6	15.6	14.4	15.0	12.8	14.4		17.2	14.5	16.0
05-Jul	15.0	15.6	14.4	15.6	12.8	14.4	14.6	17.2	14.5	16.2
06-Jul	15.6	15.0	13.9	16.1	12.8	14.4	14.5	16.7	15.0	16.4
07-Jul	15.6	15.0	13.9	15.6	12.9	14.4	15.0	16.7	15.5	16.6
08-Jul	16.1	14.4	13.9	15.6	13.0	15.0	15.3	16.7	15.7	16.8
09-Jul	16.1	14.4	14.4	15.0	13.1	15.6	15.4	16.7	16.0	16.9
10-Jul	16.1	15.0	14.4	15.0	13.2	16.1	15.3	16.4	16.3	17.1
11-Jul	15.6	13.3	15.0	15.0	13.3	16.7	15.4	16.7	16.3	17.3
12-Jul	15.6	13.9	15.6	15.0	13.3	16.1	15.3	16.7	16.1	17.5
13-Jul	15.6	15.0	16.1	14.7	13.3	16.1	15.3	17.2	16.0	17.6
14-Jul	16.1	15.0	16.1	14.4	13.3	16.1	15.4	17.8	16.4	17.4
15-Jul	16.1	15.0	15.0	15.0	13.9	16.1	15.6	17.8	16.1	17.6
16-Jul	16.1	16.1	15.6	14.4	15.0	16.7	15.6	17.8	16.1	17.8
17-Jul	16.7	16.7	15.6	14.4	15.0	16.7	15.6	17.8	16.4	17.8
18-Jul	16.7	16.7	16.1	13.9	15.0	16.1	15.8	16.7	16.7	17.9
19-Jul	16.7	17.2	16.1	15.0	15.3	16.1	16.3	16.7	16.5	17.8
20-Jul	16.1	17.2	16.1	15.6	14.4	17.2	16.6	17.2	16.7	17.6
21-Jul	16.1	17.2	16.1	15.7	14.7	17.2	16.6	16.7	17.4	17.6
22-Jul	16.1	17.8	15.6	15.6	14.4	17.8	16.7	17.8	17.5	17.8
23-Jul	17.2	17.8	15.6	16.1	14.4	17.8	16.8	17.8	17.1	17.9
24-Jul	17.2	17.8	15.0	16.7	15.0	18.9	17.0	17.8	17.4	18.1
25-Jul	17.2	16.7	15.6	16.7	15.0	18.9	17.0	17.8	17.4	18.2
26-Jul	17.2	18.3	16.1	16.7	15.0	17.8	16.6	17.8	17.2	17.9
27-Jul	17.8	18.3	16.1	17.2	16.7	17.2	16.2	18.3	17.5	17.2
28-Jul	17.8	17.8	16.7	16.7	16.7	17.2	15.9	18.3	18.1	17.2
29-Jul	17.2	17.8	17.2	16.7	17.2	17.2	15.5	18.3	17.8	17.2
30-Jul	17.8	17.8	18.3	16.7	17.8	17.8	15.4	18.3	17.6	17.1
31-Jul	17.8	17.2	18.3	17.8	17.2	17.8	16.0	18.3	17.8	17.0

Date	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
01-Aug	17.2	17.2	17.2	17.8	17.8	17.8	16.7	17.2	17.6	18.0
02-Aug	17.2	17.2	16.7	18.3	17.8	17.8	17.0	16.7	17.8	18.0
03-Aug	16.7	17.2	16.7	17.2	17.8	18.3	17.1	17.8	17.8	18.0
04-Aug	16.1	17.2	17.8	16.7	17.8	18.3	17.3	17.8	17.5	17.0
05-Aug	16.1	18.3	17.8	17.8	18.1	18.3	17.4	17.2	17.5	17.0
06-Aug	16.7	18.3	17.2	17.8	17.8	18.3	17.5	16.1	17.6	18.0
07-Aug	16.1	18.9	18.3	17.2	17.8	18.3	17.8	16.1	17.8	18.0
08-Aug	16.1	18.9	17.2	17.8	17.2	17.2	18.1	16.7	17.6	18.0
09-Aug	16.1	18.9	17.2	18.3	17.8	17.2	18.1	16.1	17.8	18.0
10-Aug	16.1	19.4	17.2	18.9	17.8	17.2	18.0	18.3	17.8	18.0
11-Aug	17.2	20.0	17.2	18.3	17.8	17.2	17.7	18.3	18.1	17.8
12-Aug	17.2	20.0	17.8	18.3	17.8	17.2	17.6	16.7	17.8	16.0
13-Aug	17.8	20.0	17.2	18.3	17.2	17.8	17.6	16.7	17.8	16.0
14-Aug	17.8	20.0	16.1	18.3	17.2	17.2	17.7	17.2	17.9	17.0
15-Aug	18.3	20.0	16.1	18.3	17.2	17.2	17.6	16.1	17.9	16.0
16-Aug	17.8	20.0	16.1	18.3	17.8	15.6	17.3	16.1	18.2	16.0
17-Aug	17.2	20.0	15.6	18.3	17.8	16.7	17.0	16.1	17.9	17.0
18-Aug	17.2	20.0	15.6	19.4	17.8	17.2	16.9	16.7	18.1	17.0
19-Aug	17.2	19.4	15.6	18.9	17.2	16.7	16.7	16.7	17.6	18.0
20-Aug	17.2	19.4	15.6	17.8	17.2	16.7	16.7	16.1	17.8	18.0
21-Aug	17.2	19.2	15.6	16.1	16.7	16.7	16.9	15.6	17.9	16.0
22-Aug	16.7	18.9	16.1	16.1	16.7	16.1	17.2	15.6	18.5	16.0
23-Aug	16.1	18.9	16.1	16.7	16.7	16.7	17.3	15.6	18.2	17.0
24-Aug	16.1	18.9	16.1	17.2	16.7	17.2	17.3	15.6	18.1	17.0
25-Aug	15.6	18.9	16.1	17.2	16.7	17.2	17.5	15.8	18.1	17.0
26-Aug	15.6	18.3	16.1	17.8	16.7	16.1	17.7	16.1	17.9	16.5
27-Aug	15.0	17.8	16.7	16.7	16.1	16.7	18.1	16.7	17.9	16.0
28-Aug	14.4	17.8	16.7	17.2	15.6	16.7	18.1	17.2	18.1	15.5
29-Aug	13.9	17.2	16.1	17.2	15.6	15.6	18.0	17.2	18.5	16.9
30-Aug	13.9	17.2	16.1	17.8	15.0	16.1	18.0	17.2	18.1	16.7
31-Aug	13.9	17.2	15.6	17.8	15.0	16.1	18.0	17.2	18.3	16.4
01-Sep	13.9	16.7	15.6	18.3	14.4	15.6	18.0	17.2	17.9	16.5
02-Sep	13.9	16.7	15.6	17.2	13.9	15.6	17.9	17.2	17.5	16.5
03-Sep	14.4	16.7	16.1	16.8	13.3	16.1	17.7	16.1	17.8	16.8
04-Sep	13.9	16.7	15.9	16.4	12.8	16.1	17.1	16.1	17.9	16.4
05-Sep	13.9	16.7	15.7	16.0	12.2	15.0	16.6	15.6	18.1	16.8
06-Sep	13.9	16.7	15.6	15.6	12.5	15.0	16.5	17.2	17.8	16.7
07-Sep	13.9	16.9	15.6	14.4	12.8	14.3	16.0	16.4	17.8	16.7
08-Sep	13.9	17.2	15.6	14.4	13.1	13.5	15.6	15.6	17.2	16.8
09-Sep	13.3	17.2	15.0	13.9	13.5	12.8	15.2	15.6	16.7	16.5
10-Sep	13.3	17.2	14.4	13.9	13.9	12.2	15.0	16.1	16.3	16.3
11-Sep	13.9	17.2	13.9	13.9	13.3	12.2	14.5	16.7	15.7	15.7
12-Sep	13.9	16.7	13.3	13.9	12.8	12.8	14.4	16.1	15.0	15.8
13-Sep	13.9	15.6	12.8	13.9	12.2	12.8	14.3	16.7	15.0	16.1
14-Sep	13.9	15.6	12.2	15.0	11.7	12.8	14.4	16.1	15.1	16.1
15-Sep	13.9	15.6	12.2	13.9	12.2	12.8	14.2	15.6	15.1	16.3
16-Sep	13.3	15.6	11.7	15.0	12.8	12.8	13.3	15.0	15.1	16.1
17-Sep	13.9	16.1	11.9	13.3	13.3	13.3	12.2	14.4	15.0	15.8
18-Sep	13.9	16.7	12.2	13.3	13.3	13.3	12.5	13.9	14.4	15.1
19-Sep	13.9	16.1	12.2	12.2	13.3	12.2	12.6	14.4	13.9	14.9
20-Sep	13.7	15.6	13.3	11.7	13.3	12.2	12.6	14.4	13.5	14.6
21-Sep	13.5	15.0	13.1	12.2	12.8	11.7	12.7	14.4	13.1	15.0
22-Sep	13.3	14.4	13.0	12.2	12.4	11.7	12.8	14.4	12.8	15.0
23-Sep	13.3	13.9	12.8	12.2	12.0	11.1	13.3	14.4	12.6	15.0
24-Sep	12.8	13.9	13.3	12.8	11.7	10.0	12.2	14.4	12.2	15.0
25-Sep	11.7	13.9	12.8	13.3	10.0	10.0	12.2	14.2	12.1	14.9
26-Sep	11.7	13.3	12.8	13.3	9.4	10.6	12.2	13.6	11.8	14.9
27-Sep	12.0	13.3	12.8	13.1	8.9	10.8	12.2	13.3	11.9	15.1
28-Sep	12.4	13.3	12.8	12.8	8.9	10.6	12.8	13.3	11.8	15.3
29-Sep	12.8	13.3	12.8	10.0		10.3	12.2	13.3	12.1	15.1
30-Sep	12.8	12.8	12.5	10.0		10.3	12.2	13.3	12.5	14.7

Date	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
01-Jun	11.4	13.0	11.7	13.6		13.9	11.1	11.0	14.1	10.1
02-Jun	11.5	12.9	12.2	13.6		13.8	11.8	11.0	13.6	10.2
03-Jun	11.4	12.8	12.1	13.6		13.6	12.1	10.9	13.5	10.6
04-Jun	11.3	12.5	12.1	13.8		13.6	12.0	10.7	13.6	10.9
05-Jun	11.0	12.4	12.3	13.9		13.4	12.1	10.5	13.9	10.8
06-Jun	11.0	12.0	11.8	14.0		13.2	12.0	10.5	14.4	10.7
07-Jun	11.5	11.9	11.7	14.2		12.5	12.6	10.7	14.2	10.5
08-Jun	12.1	12.5	11.8	14.1		12.7	12.7	10.9	14.4	10.9
09-Jun	11.7	12.1	13.7	14.2		13.1	12.0	11.2	14.9	10.6
10-Jun	11.5	11.8	14.2	14.2		13.1	11.7	11.3	15.6	10.6
11-Jun	11.8	12.4	14.4	13.9		13.5	11.8	11.6	16.1	10.5
12-Jun	11.5	12.6	14.3	13.0		13.7	12.1	11.8	16.1	10.9
13-Jun	11.7	12.4	13.9	13.4		13.8	12.0	12.0	15.9	11.4
14-Jun	12.1	12.7	13.3	13.8		13.7	11.9	12.5	15.6	11.9
15-Jun	12.6	12.5	14.4	13.9		13.9	11.7	12.7	15.2	12.4
16-Jun	13.1	12.8	15.2	14.9		14.3	11.8	12.6	14.7	12.8
17-Jun	12.8	13.0	15.4	15.0		14.2	12.2	12.5	14.7	12.8
18-Jun	11.9	12.9	15.3	15.4		14.2	12.0	12.4	14.7	13.0
19-Jun	11.3	12.5	15.3	15.6		14.1	12.0	12.6	15.0	12.9
20-Jun	11.5	12.4	15.3	15.8		14.4	12.2	12.7	15.0	12.7
21-Jun	13.1	12.8	15.6	15.5		14.5	12.3	12.5	15.1	12.5
22-Jun	13.9	13.4	16.1	15.0		15.2	12.6	12.2	15.9	12.3
23-Jun	13.9	14.0	16.5	15.1		15.9	13.0	12.2	16.5	11.9
24-Jun	14.0	14.4	16.8	15.1		15.8	13.6	12.2	16.9	11.7
25-Jun	14.4	14.2	17.1	15.3		15.7	13.5	12.7	16.8	11.6
26-Jun	14.3	14.0	17.5	15.4		15.8	13.7	13.3	16.5	11.7
27-Jun	14.4	14.4	17.9	15.7	16.6	15.5	13.7	13.6	16.3	11.9
28-Jun	14.6	14.7	18.0	15.3	16.8	15.5	13.7	13.7	16.8	11.9
29-Jun	14.7	14.7	18.0	15.0	16.5	15.9	13.8	13.7	16.9	12.4
30-Jun	14.7	15.1	17.6	14.8	15.6	16.5	14.0	13.5	17.1	12.5
01-Jul	13.7	15.4	17.5	14.8	15.4	16.7	14.2	13.8	17.4	12.6
02-Jul	13.5	16.1	17.9	15.0	15.2	16.9	14.1	14.0	17.1	12.2
03-Jul	13.5	16.0	17.8	15.1	14.4	16.8	13.8	14.4	17.4	11.8
04-Jul	13.5	15.7	17.7	15.3	14.3	16.8	13.8	14.8	17.3	11.9
05-Jul	13.8	15.7	17.1	15.7	14.2	16.8	14.0	15.2	17.6	12.5
06-Jul	13.8	15.5	16.4	15.9	13.7	16.8	14.0	15.2	18.1	13.0
07-Jul	14.0	14.9	16.5	16.3	13.9	16.8	14.3	15.5	18.6	12.9
08-Jul	14.2	15.0	17.1	16.5	14.2	17.0	14.4	15.5	19.1	12.7
09-Jul	14.5	15.4	17.6	16.4	14.7	17.4	14.2	15.5	19.2	13.1
10-Jul	15.0	15.6	17.6	16.3	14.7	17.1	14.4	15 2	18.9	13.5
11-Jul	15.3	15.9	17.7	16.2	14.9	17.1	14.9	14.5	19.1	13.7
12-Jul	15.5	16.2	17.8	16.3	15.3	17.1	15.5	14.4	18.8	13.8
13-Jul	16.0	16.6	17.4	16.4	15.8	17.3	15.5	14.9	18.6	13.9
14-Jul	16.4	16.8	17.6	16.1	16.4	17.3	15.8	15.1	18.3	13.9
15-Jul	16.5	16.5	18.1	16.3	16.7	17.1	15.9	14.9	18.0	13.4
16-Jul	16.2	16.6	18.3	16.8	17.1	17.3	15.6	14.6	18.0	13.3
17-Jul	16.4	16.5	18.5	17.2	17.4	17.5	15.1	14.1	18.4	13.2
18-Jul	16.0	16.3	19.2	17.3	17.7	17.9	15.3	14.5	18.5	13.4
19-Jul	15.9	16.4	19.4	17.1	17.7	17.9	15.2	15.1	18.7	13.9
20-Jul	15.6	16.7	18.9	17.0	17.8	18.3	15.2	15.5	18.8	14.4
21-Jul	16.0	16.9	18.6	17.2	18.3	18.5	15.3	15.7	18.8	14.8
22-Jul	16.5	16.7	19.1	17.3	18.7	18.5	15.5	16.1	19.0	15.2
23-Jul	16.8	17.0	18.8	18.4	18.4	19.1	15.2	16.4	19.5	15.8
24-Jul	16.6	17.1	19.2	18.4	19.0	19.1	15.6	16.4	19.7	15.7
25-Jul	16.4	17.4	19.8	18.6	19.5	19.0	15.8	16.0	19.8	15.2
26-Jul	16.2	17.9	20.2	18.4	19.7	18.4	16.5	15.5	20.3	15.5
27-Jul	16.3	17.7	20.0	18.5	19.7	18.2	17.3	15.5	20.7	15.6
28-Jul	16.2	18.1	19.9	18.6	19.9	18.0	17.8	15.8	20.9	15.6
29-Jul	17.5	17.9	20.0	18.4	20.0	17.5	18.4	16.1	21.1	15.5
30-Jul	18.2	18.0	20.2	18.0	19.7	16.7	18.4	16.5	21.0	15.4
31-Jul	18.2	17.8	20.4	18.0	19.4	16.4	18.1	17.1	21.0	15.5

Date	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
01-Aug	17.9	17.7	20.3	18.2	19.3	16.7	17.8	17.3	20.9	15.3
02-Aug	17.7	17.7	20.3	18.3	19.5	16.9	17.2	17.0	21.0	14.9
03-Aug	17.9	17.7	20.5	18.2	19.4	16.9	16.5	17.1	21.2	15.2
04-Aug	18.0	17.8	20.2	18.1	19.4	17.2	16.2	17.6	21.1	15.5
05-Aug	18.2	18.3	20.1	18.4	19.6	17.3	15.7	17.6	20.9	15.8
06-Aug	18.4	18.7	19.8	18.9	19.9	16.7	15.9	17.6	20.4	16.9
07-Aug	18.5	18.6	19.7	19.3	19.7	16.3	16.5	17.8	20.1	17.2
08-Aug	18.4	18.7	19.4	19.5	19.0	16.5	16.8	17.9	19.9	17.3
09-Aug	18.5	18.9	19.0	19.6	18.4	16.3	16.9	17.3	19.9	18.0
10-Aug	18.5	18.2	18.7	18.8	18.5	16.4	17.0	17.2	19.5	18.3
11-Aug	18.5	17.5	19.1	18.2	18.7	16.5	17.1	17.4	19.3	18.0
12-Aug	18.8	17.1	19.3	18.0	18.9	16.5	17.2	17.5	19.5	17.8
13-Aug	19.0	17.4	19.5	18.0	19.2	16.1	17.8	17.8	19.8	17.5
14-Aug	19.2	17.6	20.0	17.9	19.3	16.4	18.1	18.1	20.0	17.1
15-Aug	19.3	17.8	20.1	17.8	19.2	16.5	17.9	18.2	19.8	17.0
16-Aug	19.1	18.2	20.3	17.6	19.2	16.5	17.3	17.8	19.3	16.7
17-Aug	19.0	18.5	20.3	17.9	18.9	16.2	17.0	17.8	18.9	17.1
18-Aug	18.2	18.6	20.0	18.3	19.0	15.7	16.5	17.7	18.4	17.4
19-Aug	18.5	18.9	20.0	18.8	19.5	15.4	16.5	17.7	17.9	17.8
20-Aug	18.4	19.2	20.1	19.3	19.2	15.7	16.6	17.8	18.2	18.1
21-Aug	18.6	19.2	19.5	19.4	19.1	16.0	16.3	18.0	18.3	17.7
22-Aug	18.3	18.9	18.7	19.2	18.5	15.9	16.4	18.1	18.5	17.7
23-Aug	18.2	18.8	17.9	18.9	18.3	16.1	16.7	18.0	18.7	17.9
24-Aug	17.8	18.4	17.0	18.0	18.8	15.9	16.8	17.9	18.8	18.2
25-Aug	17.7	17.8	16.7	17.6	18.6	15.6	16.8	17.7	18.6	18.0
26-Aug	16.8	17.4	16.9	17.1	18.3	15.9	17.2	17.5	18.5	17.4
27-Aug	17.0	17.1	17.2	17.0	18.0	16.0	17.6	17.5	18.6	17.2
28-Aug	16.9	16.9	17.6	16.7	17.7	16.2	17.6	17.3	18.6	17.2
29-Aug	16.8	16.6	17.6	16.0	17.4	16.0	17.7	17.2	18.6	17.0
30-Aug	16.5	16.4	17.1	16.1	17.6	15.8	17.7	17.0	18.6	15.9
31-Aug	16.3	15.7	16.9	16.2	18.0	16.0	17.4	16.9	18.6	15.2
01-Sep	16.0	15.1	17.0	16.5	18.3	16.2	17.0	17.1	18.6	14.9
02-Sep	15.9	15.3	17.2	16.8	18.3	16.3	16.9	17.2	18.6	15.1
03-Sep	15.9	15.6	17.2	17.3	18.0	16.5	16.4	16.9	18.8	15.0
04-Sep	16.1	15.7	17.1	17.7	17.8	16.8	15.6	16.8	18.7	14.7
05-Sep	16.1	15.8	16.5	17.5	17.7	17.0	15.0	17.0	18.4	15.0
06-Sep	16.1	15.9	15.6	17.4	17.6	17.1	14.5	16.7	18.1	15.3
07-Sep	16.1	15.9	15.0	17.4	17.4	17.4	14.7	16.8	17.9	15.2
08-Sep	16.0	15.8	14.6	17.6	16.8	17.2	15.0	16.7	17.8	15.0
09-Sep	16.0	15.6	14.4	17.7	15.8	17.4	15.1	16.5	17.5	14.9
10-Sep	15.6	15.5	14.7	17.5	15.2	17.6	15.1	16.6	16.7	15.1
11-Sep	16.3	15.7	14.7	17.4	15.3	17.7	15.1	16.8	16.5	14.8
12-Sep	16.3	15.7	14.5	16.6	15.6	17.7	15.1	16.4	16.9	14.2
13-Sep	16.3	15.7	14.1	16.0	15.7	17.5	15.0	15.9	17.0	14.1
14-Sep	16.3	15.6	13.4	15.6	15.5	17.4	14.8	15.7	17.2	14.2
15-Sep	16.3	15.4	12.8	15.5	15.8	17.4	14.5	15.5	16.9	14.4
16-Sep	16.0	15.3	12.1	15.4	15.9	17.2	14.4	15.3	16.6	14.6
17-Sep	15.8	15.5	11.9	14.8	16.0	16.4	14.2	15.0	16.3	14.9
18-Sep	15.4	15.8	11.8	14.6	16.1	16.4	13.8	14.7	15.8	14.9
19-Sep	15.4	15.7	11.8	14.5	16.2	16.1	13.6	14.2	15.5	14.9
20-Sep	15.5	15.7	11.9	14.0	16.1	15.5	13.4	13.7	15.5	15.0
21-Sep	15.8	15.4	12.6	13.6	15.8	14.6	13.1	13.8	15.4	15.3
22-Sep	15.8	14.6	13.2	13.1	15.7	14.3	12.6	14.1	15.2	15.4
23-Sep	15.9	14.1	13.1	13.2	15.7	14.2	12.3	14.4	15.1	15.4
24-Sep	15.9	14.2	12.4	13.1	15.6	13.8	12.0	14.5	14.8	15.0
25-Sep	15.8	14.5	11.7	13.0	15.8	14.1	12.1	14.8	14.9	14.2
26-Sep	15.7	14.7	11.5	13.2	15.7	14.2	12.2	15.1	14.8	13.9
27-Sep	15.5	14.5	11.4	13.5	15.6	14.2	12.5	14.5	14.5	13.1
28-Sep	15.5	14.7	11.3	13.8	15.7	14.5	12.8	14.5	14.4	12.5
29-Sep	15.5	14.9	11.0	14.0	15.4	14.3	13.0	14.5	14.4	12.2
30-Sep	15.2	14.7	11.2	13.9	15.0	14.1	12.6	14.3	14.4	12.3

Date	2000	2001	2002	2003	2004	2005	2006
01-Jun	11.3	11.7	10.5	11.6	12.1	14.2	12.9
02-Jun	11.4	11.1	10.4	11.9	12.5	13.7	12.9
03-Jun	11.7	11.1	10.2	11.8	12.8	13.4	12.5
04-Jun	12.3	11.1	10.5	11.9	13.2	13.2	12.6
05-Jun	12.9	11.4	11.0	12.1	13.5	12.9	12.5
06-Jun	12.7	11.7	10.8	12.2	13.8	12.6	13.0
07-Jun	12.9	11.8	11.1	12.6	14.2	13.1	12.9
08-Jun	13.2	12.0	10.8	13.2	13.8	12.6	12.7
09-Jun	13.1	12.4	10.4	13.5	14.0	13.1	12.4
10-Jun	12.3	12.6	10.4	13.8	13.7	13.7	12.8
11-Jun	11.9	12.2	10.9	13.4	13.2	13 8	13.3
12-Jun	11.9	12.0	11.4	13.7	13.5	14.0	13.9
13-Jun	12.2	12.0	12.2	13.6	14.1	13.9	14.2
14-Jun	12.0	12.4	12.9	13.5	14.0	13.8	14.0
15-Jun	12.0	12.4	13.2	13.3	13.8	13.7	13.8
16-Jun	11.9	12.6	13.4	13.6	13.6	14.1	14.3
17-Jun	11.9	12.9	13.2	13.7	14.0	14.3	14.4
18-Jun	12.2	12.9	13.0	14.1	14.3	13.5	14.6
19-Jun	12.0	13.1	12.7	14.1	14.6	13.8	13.8
20-Jun	12.4	13.8	12.6	14.0	15.0	14.9	13.7
21-Jun	13.0	14.1	12.4	13.8	15.5	15.5	14.0
22-Jun	12.8	14.5	12.5	13.6	16.4	15.7	14.5
23-Jun	12.8	14.5	12.6	13.7	16.7	15.6	14.8
24-Jun	12.8	14.6	13.0	14.0	17.3	15.7	14.8
25-Jun	12.7	14.4	13.5	14.3	17.4	15.7	15.1
26-Jun	13.1	14.4	14.0	14.5	17.5	15.2	16.2
27-Jun	13.8	14.5	14.0	14.8	17.8	15.3	16.3
28-Jun	14.6	14.5	13.8	15.1	17.9	15.1	16.1
29-Jun	15.1	14.5	13.7	15.4	17.2	15.3	17.0
30-Jun	15.0	14.9	13.7	15.7	17.0	15.8	16.9
01-Jul	15.0	14.9	13.7	15.5	17.4	16.0	17.3
02-Jul	14.5	15.3	13.4	15.5	18.3	16.1	17.6
03-Jul	14.2	15.5	13.3	15.4	18.3	15.8	17.7
04-Jul	13.8	16.0	12.9	15.5	17.8	16.0	17.8
05-Jul	13.4	16.1	12.9	15.5	17.5	16.1	18.0
06-Jul	13.6	16.3	13.2	15.2	18.0	15.9	18.4
07-Jul	13.4	16.1	13.6	15.4	17.7	15.7	18.8
08-Jul	13.7	16.3	13.6	15.7	16.6	15.7	18.7
09-Jul	14.4	16.5	13.8	15.4	16.5	15.8	18.4
10-Jul	14.4	16.8	14.4	15.9	16.7	15.8	18.4
11-Jul	14.6	17.2	15.6	16.8	16.7	15.5	18.3
12-Jul	15.1	17.1	16.0	17.2	16.4	15.4	18.0
13-Jul	15.6	17.1	16.0	17.2	16.9	15.6	17.7
14-Jul	15.3	17.6	16.3	17.0	17.5	15.8	17.2
15-Jul	15.3	17.5	16.7	17.4	18.0	16.0	17.0
16-Jul	15.2	16.8	16.5	17.5	18.3	16.3	17.1
17-Jul	15.8	16.7	16.3	17.5	18.6	16.2	17.2
18-Jul	16.0	16.5	16.5	17.6	19.2	16.1	17.2
19-Jul	16.0	16.8	16.5	17.6	19.5	16.6	17.2
20-Jul	16.2	16.8	16.7	17.4	19.5	16.6	17.3
21-Jul	16.8	16.3	16.8	17.4	19.4	16.8	18.0
22-Jul	17.3	15.4	16.8	17.7	19.5	16.7	18.6
23-Jul	17.0	15.4	16.8	17.8	19.8	16.5	19.4
24-Jul	17.2	15.7	17.2	18.4	19.9	17.1	20.0
25-Jul	17.8	16.0	17.6	18.9	20.0	17.1	20.2
26-Jul	17.7	16.2	17.9	18.8	19.9	17.1	20.2
27-Jul	17.4	16.7	18.2	18.5	19.6	17.5	20.4
28-Jul	17.0	16.7	18.1	18.8	19.6	17.8	20.4
29-Jul	16.9	16.5	18.0	19.3	19.9	17.7	19.7
30-Jul	17.2	16.4	17.6	19.5	20.0	17.8	19.2
31-Jul	17.2	16.3	16.9	19.8	20.1	18.0	18.6

Date	2000	2001	2002	2003	2004	2005	2006
01-Aug	17.5	16.4	16.4	20.1	20.2	18.2	18.5
02-Aug	17.5	16.1	16.0	20.2	20.3	17.9	18.7
03-Aug	17.2	16.3	15.6	20.1	20.2	17.8	18.3
04-Aug	17.0	16.6	15.3	20.0	20.1	17.7	18.4
05-Aug	17.2	16.7	15.1	20.0	20.2	18.0	18.1
06-Aug	18.1	16.6	15.4	19.7	19.8	18.2	18.1
07-Aug	18.6	16.4	15.2	19.3	19.2	18.4	18.2
08-Aug	18.8	16.4	15.7	19.4	19.2	18.6	18.6
09-Aug	19.0	16.2	16.5	19.4	19.6	18.6	18.2
10-Aug	19.1	16.3	17.3	19.1	19.3	18.5	18.2
11-Aug	18.5	16.9	17.3	18.9	19.6	18.2	17.6
12-Aug	18.1	17.4	17.3	19.2	19.8	18.3	17.7
13-Aug	18.1	18.0	17.2	19.1	19.9	18.4	18.0
14-Aug	17.7	18.4	17.4	18.8	20.5	18.7	18.3
15-Aug	17.6	18.7	17.2	18.8	20.9	19.0	18.4
16-Aug	17.5	19.1	17.1	19.1	21.2	19.3	18.4
17-Aug	17.4	19.3	17.1	19.2	21.4	19.1	18.3
18-Aug	17.4	19.1	16.7	19.3	21.5	18.7	18.5
19-Aug	17.2	18.9	16.8	19.4	21.5	18.1	18.7
20-Aug	17.0	18.5	16.5	19.3	21.4	18.1	19.0
21-Aug	16.9	17.9	16.5	19.1	21.2	18.3	19.1
22-Aug	17.1	17.6	17.0	18.9	20.8	18.4	19.0
23-Aug	17.5	17.2	17.7	18.2	20.1	17.9	18.8
24-Aug	17.7	16.5	18.1	17.7	19.2	17.2	18.7
25-Aug	17.5	16.4	18.6	17.3	18.4	17.0	18.8
26-Aug	17.3	16.4	18.7	17.1	18.1	17.0	18.8
27-Aug	17.1	16.5	19.1	17.1	18.0	17.0	18.6
28-Aug	16.6	16.8	19.3	17.4	17.7	17.3	18.5
29-Aug	15.9	16.8	19.3	17.2	17.8	17.3	18.5
30-Aug	15.9	16.9	19.1	17.3	17.9	17.2	18.0
31-Aug	15.7	17.0	18.6	17.6	17.9	16.8	17.6
01-Sep	15.1	16.8	17.9	17.9	17.7	17.0	17.3
02-Sep	14.8	16.6	17.7	17.6	17.1	16.8	17.3
03-Sep	14.3	16.5	17.0	17.5	16.2	16.6	17.3
04-Sep	13.9	16.4	16.8	17.7	15.6	16.2	17.6
05-Sep	13.8	16.4	16.3	18.0	15.7	16.0	17.6
06-Sep	13.8	15.8	15.5	18.1	15.4	15.7	18.1
07-Sep	14.0	15.2	15.1	18.0	15.3	15.6	18.1
08-Sep	13.8	15.1	14.8	17.8	15.3	15.7	18.1
09-Sep	13.6	15.0	14.4	17.3	15.1	15.8	18.1
10-Sep	13.4	14.9	14.4	16.9	14.9	15.2	17.8
11-Sep	13.4	14.6	14.8	16.5	14.3	15.0	17.5
12-Sep	13.0	14.3	15.1	16.1	14.0	15.0	17.6
13-Sep	12.6	14.6	15.3	15.8	13.5	15.1	17.5
14-Sep	12.6	14.6	15.2	15.4	13.4	14.9	16.4
15-Sep	12.7	14.8	15.2	14.9	13.1	14.7	15.4
16-Sep	12.8	15.0	15.3	14.5	13.3	14.7	14.6
17-Sep	13.4	15.2		14.2	13.2	14.6	14.1
18-Sep	13.9	15.3	14.9	13.3	13.0	14.4	13.6
19-Sep	14.3	15.5	14.8	13.2	12.5	14.1	13.7
20-Sep	14.2	15.4	14.5	13.5	12.3	14.0	13.7
21-Sep	13.8	15.0	13.9	13.5	12.1	13.8	13.5
22-Sep	12.9	15.2	13.3	13.6	12.4	13.7	13.7
23-Sep	12.2	15.6	12.5	13.5	12.7	13.1	13.9
24-Sep	11.8	15.7	11.9	13.1	12.8	12.6	14.2
25-Sep	11.8	15.6	12.1	13.0	12.8	12.4	14.1
26-Sep	11.9	15.3	11.9	12.8	12.9	12.5	14.4
27-Sep	12.2	14.9	11.7	12.5	12.7	12.8	14.7
28-Sep	12.4	14.4	11.8	12.5	12.7	12.5	15.0
29-Sep	12.6	14.1	12.0	12.9	12.8	12.3	15.0
30-Sep	12.9	13.8	11.9	12.8	12.7	12.3	14.9

Date	Mean	Count	S.D.	Min		Max
01-Jun	11.3	57	1.32	7.8	-	14.2
02-Jun	11.5	53	1.27	8.3	-	13.9
03-Jun	11.5	55	1.18	9.0	-	13.6
04-Jun	11.5	57	1.22	9.2	-	14.3
05-Jun	11.6	56	1.23	9.3	-	14.4
06-Jun	11.7	55	1.29	9.6	-	14.7
07-Jun	11.8	56	1.28	9.8	-	14.2
08-Jun	12.0	54	1.33	9.9	-	14.6
09-Jun	12.1	54	1.33	10.0	-	14.9
10-Jun	12.1	56	1.34	9.4	-	15.6
11-Jun	12.1	56	1.31	9.4	-	16.1
12-Jun	12.3	54	1.27	9.7	-	16.1
13-Jun	12.3	56	1.28	9.7	-	15.9
14-Jun	12.4	57	1.20	10.1	-	15.6
15-Jun	12.6	56	1.16	10.3	-	15.2
16-Jun	12.7	55	1.30	10.3	-	15.2
17-Jun	12.9	55	1.30	10.6	-	15.7
18-Jun	12.9	55	1.30	10.6	-	15.8
19-Jun	13.1	54	1.39	10.6	-	16.4
20-Jun	13.2	55	1.49	10.7	-	16.3
21-Jun	13.4	55	1.47	11.0	-	16.5
22-Jun	13.6	55	1.50	11.1	-	16.7
23-Jun	13.7	55	1.54	11.7	-	17.4
24-Jun	13.8	53	1.56	11.4	-	17.5
25-Jun	13.8	55	1.52	11.6	-	17.8
26-Jun	13.9	54	1.53	11.7	-	18.1
27-Jun	14.0	57	1.57	11.4	-	17.9
28-Jun	14.1	57	1.52	11.7	-	18.0
29-Jun	14.2	58	1.48	11.5	-	18.0
30-Jun	14.2	56	1.50	11.0	-	17.6
01-Jul	14.3	56	1.57	10.7	-	17.5
02-Jul	14.4	60	1.67	11.0	-	18.3
03-Jul	14.5	65	1.74	11.6	-	18.3
04-Jul	14.6	65	1.62	11.7	-	18.0
05-Jul	14.8	67	1.60	11.9	-	18.0
06-Jul	14.8	66	1.55	12.2	-	18.4
07-Jul	15.1	67	1.61	12.2	-	18.8
08-Jul	15.2	66	1.61	12.2	-	19.1
09-Jul	15.3	66	1.57	12.2	-	19.2
10-Jul	15.4	66	1.49	12.8	-	18.9
11-Jul	15.6	65	1.51	12.8	-	19.4
12-Jul	15.6	65	1.42	13.3	-	19.4
13-Jul	15.7	66	1.37	12.8	-	18.9
14-Jul	15.8	66	1.34	12.8	-	18.3
15-Jul	15.9	65	1.36	12.8	-	18.3
16-Jul	15.9	66	1.37	13.3	-	18.9
17-Jul	16.1	66	1.47	13.2	-	21.0
18-Jul	16.2	66	1.54	13.3	-	21.0
19-Jul	16.4	67	1.51	13.3	-	20.5
20-Jul	16.4	65	1.45	13.3	-	20.0
21-Jul	16.5	66	1.40	12.8	-	19.4
22-Jul	16.7	66	1.48	13.3	-	20.0
23-Jul	16.8	65	1.53	13.3	-	19.8
24-Jul	17.0	67	1.54	13.3	-	20.0
25-Jul	17.0	67	1.52	13.9	-	20.2
26-Jul	17.0	66	1.49	13.9	-	20.3
27-Jul	17.2	67	1.47	13.9	-	20.7
28-Jul	17.3	65	1.44	14.4	-	20.9
29-Jul	17.3	65	1.39	14.4	-	21.1
30-Jul	17.3	64	1.41	14.4	-	21.0
31-Jul	17.4	67	1.31	15.0	-	21.0

Date	Mean	Count	S.D.	Min		Max
01-Aug	17.5	66	1.31	14.6	-	20.9
02-Aug	17.5	66	1.37	14.3	-	21.0
03-Aug	17.5	67	1.40	14.3	-	21.2
04-Aug	17.5	64	1.38	14.2	-	21.1
05-Aug	17.5	64	1.35	14.6	-	20.9
06-Aug	17.6	64	1.29	14.2	-	20.4
07-Aug	17.6	67	1.22	14.7	-	20.1
08-Aug	17.7	66	1.17	14.7	-	19.9
09-Aug	17.7	68	1.23	14.2	-	19.9
10-Aug	17.7	67	1.16	14.6	-	19.5
11-Aug	17.8	66	1.07	15.0	-	20.0
12-Aug	17.7	63	1.11	15.4	-	20.0
13-Aug	17.7	68	1.20	15.2	-	20.0
14-Aug	17.7	69	1.30	14.5	-	20.5
15-Aug	17.6	67	1.29	15.4	-	20.9
16-Aug	17.6	66	1.36	15.0	-	21.2
17-Aug	17.5	68	1.34	14.6	-	21.4
18-Aug	17.5	68	1.35	15.0	-	21.5
19-Aug	17.4	68	1.40	15.0	-	21.5
20-Aug	17.5	66	1.41	15.0	-	21.4
21-Aug	17.2	66	1.52	14.9	-	21.2
22-Aug	17.3	65	1.41	14.7	-	20.8
23-Aug	17.1	67	1.32	14.7	-	20.1
24-Aug	17.0	66	1.33	14.3	-	19.4
25-Aug	16.9	63	1.29	14.2	-	18.9
26-Aug	16.7	66	1.24	14.2	-	18.9
27-Aug	16.7	65	1.19	14.2	-	19.1
28-Aug	16.6	65	1.28	13.9	-	19.3
29-Aug	16.5	65	1.30	13.6	-	19.3
30-Aug	16.4	64	1.25	13.5	-	19.1
31-Aug	16.2	66	1.31	13.1	-	18.6
01-Sep	16.2	66	1.34	12.9	-	18.6
02-Sep	16.1	65	1.28	13.1	-	18.6
03-Sep	16.0	64	1.26	13.1	-	18.8
04-Sep	15.8	64	1.35	12.8	-	18.7
05-Sep	15.8	63	1.33	12.2	-	18.4
06-Sep	15.7	64	1.32	12.5	-	18.3
07-Sep	15.6	64	1.33	12.7	-	18.1
08-Sep	15.4	64	1.35	12.7	-	18.1
09-Sep	15.1	64	1.41	12.1	-	18.1
10-Sep	15.1	64	1.34	12.2	-	17.8
11-Sep	15.0	62	1.37	12.2	-	17.8
12-Sep	14.9	63	1.35	12.2	-	17.7
13-Sep	14.7	62	1.34	12.2	-	17.5
14-Sep	14.6	63	1.32	11.7	-	17.4
15-Sep	14.4	64	1.29	12.2	-	17.4
16-Sep	14.3	63	1.32	11.7	-	17.2
17-Sep	14.2	64	1.26	11.9	-	16.7
18-Sep	14.0	62	1.26	11.7	-	16.7
19-Sep	13.9	63	1.26	11.7	-	16.5
20-Sep	13.8	65	1.20	11.5	-	16.1
21-Sep	13.7	64	1.22	11.3	-	16.1
22-Sep	13.5	64	1.21	10.8	-	16.1
23-Sep	13.4	64	1.32	10.6	-	16.1
24-Sep	13.1	64	1.36	10.0	-	15.9
25-Sep	13.0	63	1.47	10.0	-	15.8
26-Sep	13.0	63	1.51	9.4	-	15.7
27-Sep	12.8	64	1.58	8.9	-	15.6
28-Sep	12.7	64	1.63	8.9	-	15.7
29-Sep	12.6	63	1.63	8.9	-	15.5
30-Sep	12.5	62	1.58	8.9	-	15.2